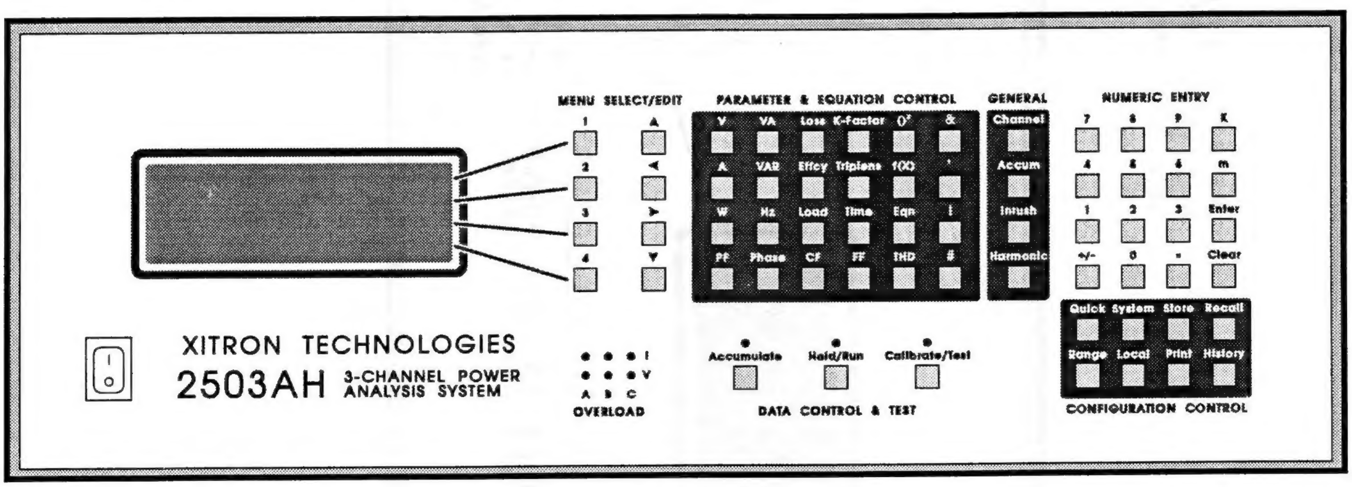
Xitron Technologies Inc

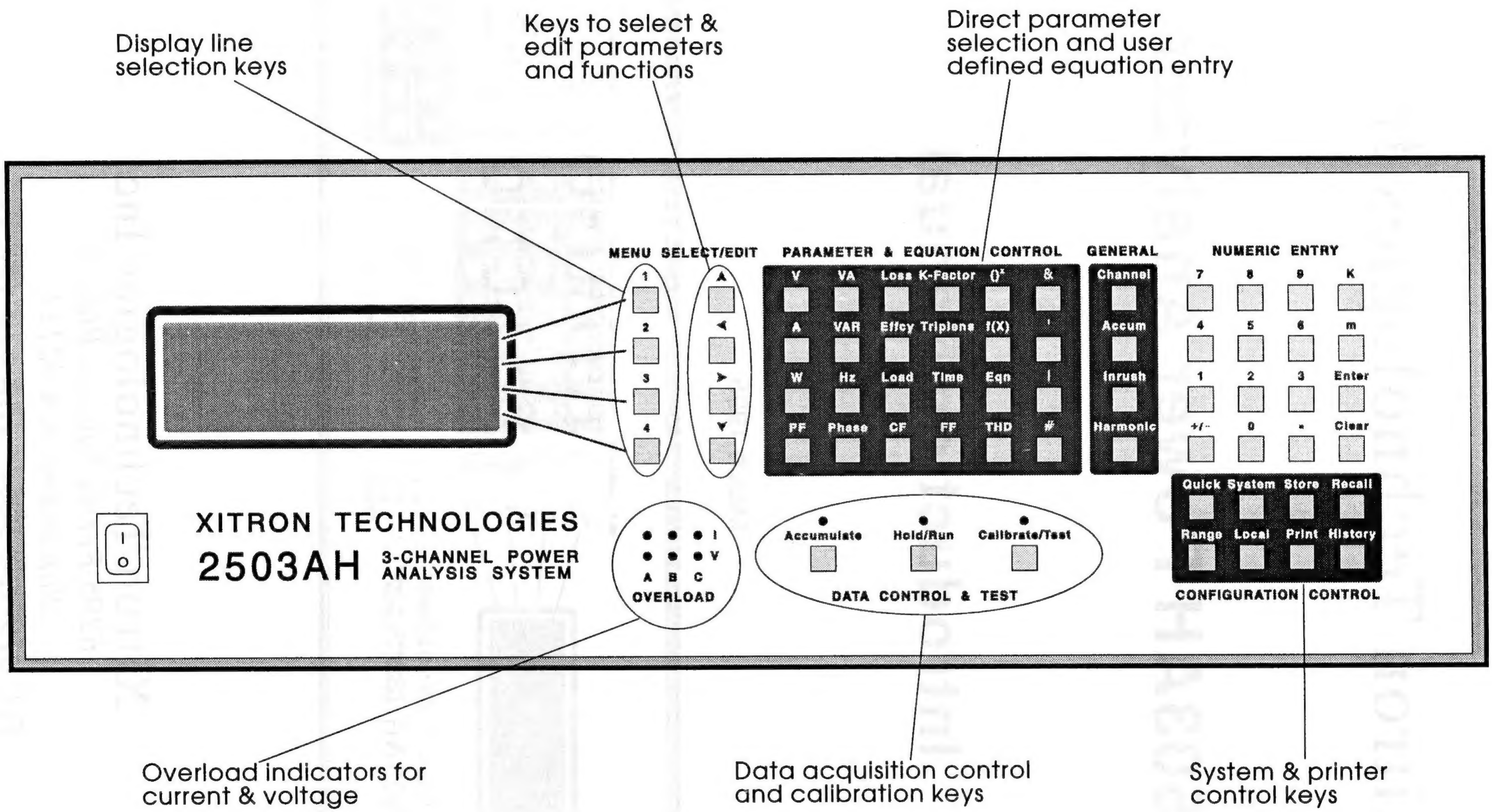
2503AH Power Analyzer

Introduction Manual

March 1995



Xitron Technologies Inc
6295 Ferris Square, Bldg D
San Diego CA 92121
Tel: 619-458-9852 FAX 619-458-9213



Display line selection keys
Keys to select & edit parameters and functions
Direct parameter selection and user defined equation entry
MENU SELECT/EDIT
PARAMETER & EQUATION CONTROL
V VA Loss K-Factor ()² &
A VAR Effcy Triplens f(X)
W Hz Load Time Eqn
PF Phase CF FF THD #
GENERAL
Channel
Accum
Inrush
Harmonic
NUMERIC ENTRY
7 8 9 K
4 5 6 m
1 2 3 Enter
+/- 0 . Clear
Quick System Store Recall
Range Local Print History
CONFIGURATION CONTROL
XITRON TECHNOLOGIES
2503AH 3-CHANNEL POWER ANALYSIS SYSTEM
I
V
A B C
OVERLOAD
Accumulate
Hold/Run
Calibrate/Test
DATA CONTROL & TEST
Overload indicators for current & voltage
Data acquisition control and calibration keys
System & printer control keys

Introduction

Operating the 2503AH family of power analyzers is very easy, once you have grasped the basic concepts of the instrument's design. The 2503AH family has pre-programmed "Quick" configurations which allow the user to quickly configure the analyzer for a number of applications. The standard and advanced setup capability lets you "tweak" every capability the analyzer offers, so that you can fully optimize the instrument for a given analysis task. The IEC555.2 and IEC555.3 setup lets you configure the instrument for measurements in accordance with these standards.

Even though many users are just interested in quickly setting up measurements for their particular application, a little more understanding of the analyzer's capabilities will allow you to optimize measurement accuracy and speed. Also, a good understanding of the instrument's operation helps you to avoid making erroneous measurements.

We will first review the theory of operation for the 2503AH family of power analyzers. The operational theory will be discussed on a building block level. It's not necessary to review the operation down to the component level, and it would be rather time consuming to discuss every aspect of a fairly complex instrument. However, the critical functions of each building block will be reviewed in more detail, often using a particular measurement as an example.

These more detailed discussions will accomplish two goals. The user will gain a better understanding of power analysis applications, and secondly, the operational limits of the analyzer will be reviewed in the process. With this knowledge, the user will be better armed to interpret test results.

Several application examples will be used in explaining how the 2503AH functions. It's impossible to review the multitude of power analysis applications, in which Xitron analyzers are used. If you find insufficient information in this manual, regarding the instrument's operation for your specific application, please contact Xitron Customer Service for assistance.

Operational Concepts

This section describes how the 2503AH functions. After reading the following explanation, you will easily understand why the instrument is the fastest, and most advanced power analyzer on the market. We will review a 3 channel (3 phase) analyzer, i.e. the 2503AH, but the same basic theory applies to the single channel 2501AH and two channel 2502AH instruments.

There are at least three main building blocks in power analyzers. Although they are closely intertwined, one may distinguish the input circuitry, data conversion & sampling, and the data analysis & display sections, as specific instrument building blocks (Fig. 1). In addition, the analyzer may have analog and digital control inputs/interfaces, and auxiliary functions such as data logging or waveform capture & display capabilities. The three main building blocks determine the instrument's performance, while the additional functions may enhance the analyzer's utility. We will primarily concentrate on the key building blocks, and review all the "bells & whistles" later.

The operational concept of the 2503AH family

Each analyzer has one or more channels, and a central processing unit which services the channels, the display/keyboard, computer interfaces, and optional functions such as data logging and analog or digital I/O. Each channel is pretty much an independent power analyzer, and has its own input scaling, supervisory, and data analysis functions. Therefore, two of the three key building blocks, being the signal conditioning and the measurement/analysis functions, are performed in every individual channel/phase. The input circuitry of every channel provides for signal scaling/ranging, including attenuation and/or gain stages. The scaling is controlled from the "channel supervisor" circuitry. Every channel has a pair of 8 bit A/D converters which operate at a fixed 2 MHz sampling rate, and are used for scaling and data sampling (synchronization) purposes.

The scaled voltage and current signals are converted into digital data by **18 bit** A/D converter circuitry/chips. The sampling rate of these 18 bit A/D converters is automatically controlled by a dedicated sampling rate generation circuit. A dedicated DSP chip, located in the supervisory circuit, measures the fundamental frequency of the selected input signal. The sampling rate of the 18 bit A/D's is adjusted, to be synchronous with the fundamental frequency of the selected input voltage/current. Every channel can be set to use its own input, or use one of the other channels as the synchronization source. Data is sampled with a rate from 250 KHz - 500 KHz. Each channel also has a data analysis section with a second DSP chip to analyze the voltage and current input samples for their harmonic content. The DSP chip implements a Fast Fourier Transform, making all voltage and current harmonics available in a matter of milliseconds.

So, one channel actually consists of three PC boards, each plugging into the analyzer's backplane. The INPUT SCALING Pcb has the shunts, attenuation and gain circuits. The INPUT SUPERVISOR Pcb has the 8 bit A/D's, along with associated filtering circuits, and the first DSP chip. The third Pcb is the AMPLITUDE MEASUREMENT DSP which performs all the harmonic analysis.

Every channel communicates the measurement and analysis results to the central processing unit, via very high speed communication links. The CPU then updates the display, digital interfaces, and prints out data as required. Because this CPU doesn't have to perform any analysis functions, it can service all interface and display functions very efficiently.

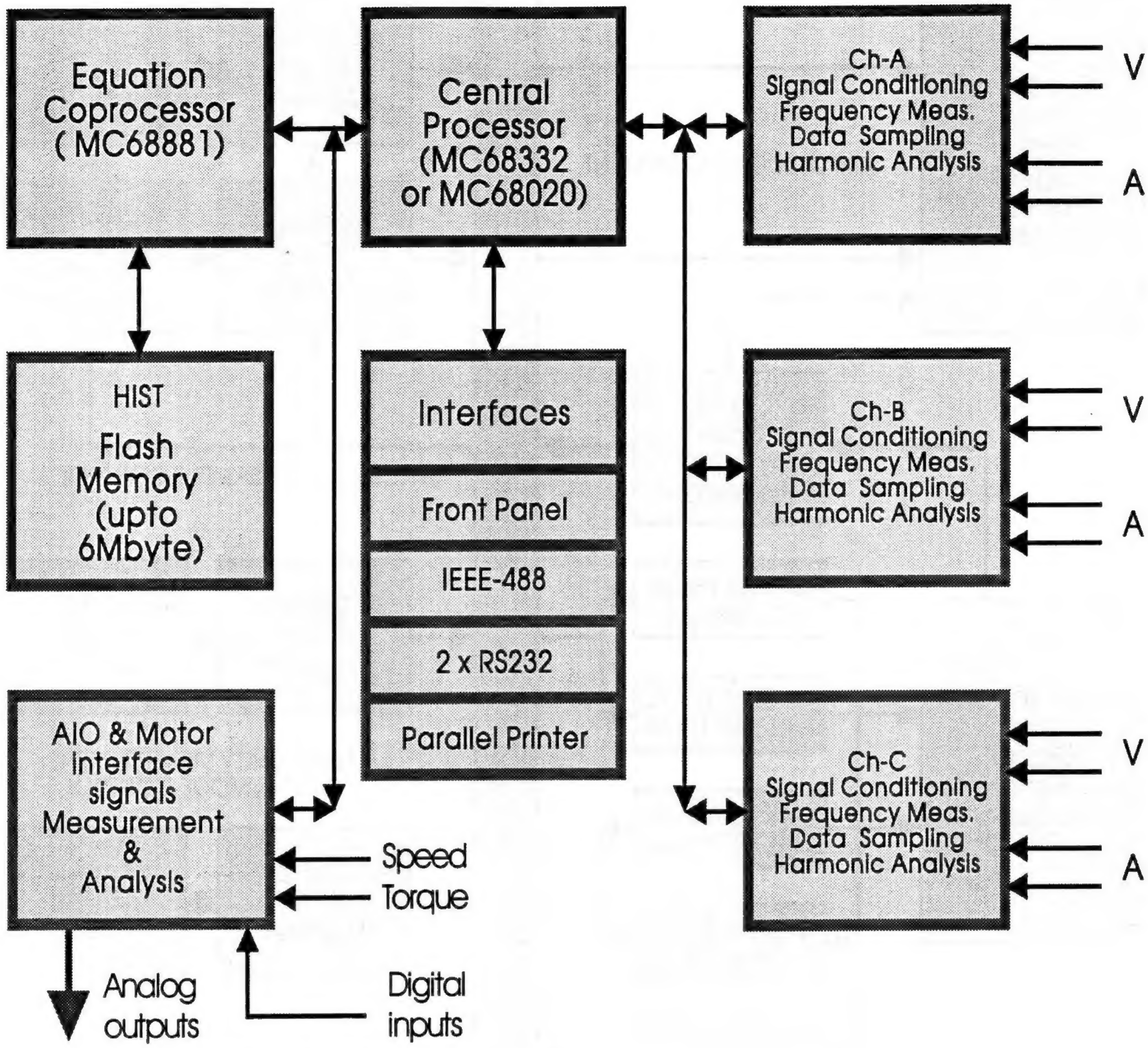


Fig. 1

2503AH System Block Diagram

The 2503AH power analyzers have independent digital signal (DSP) processors for each channel (phase) to measure/analyze the input signals.

Channels communicate their measurement & analysis results to the Central Processor, which manages & controls display & interface functions.

Optional functions and I/O capabilities can be added as desired, and communicate also with the Central Processor.

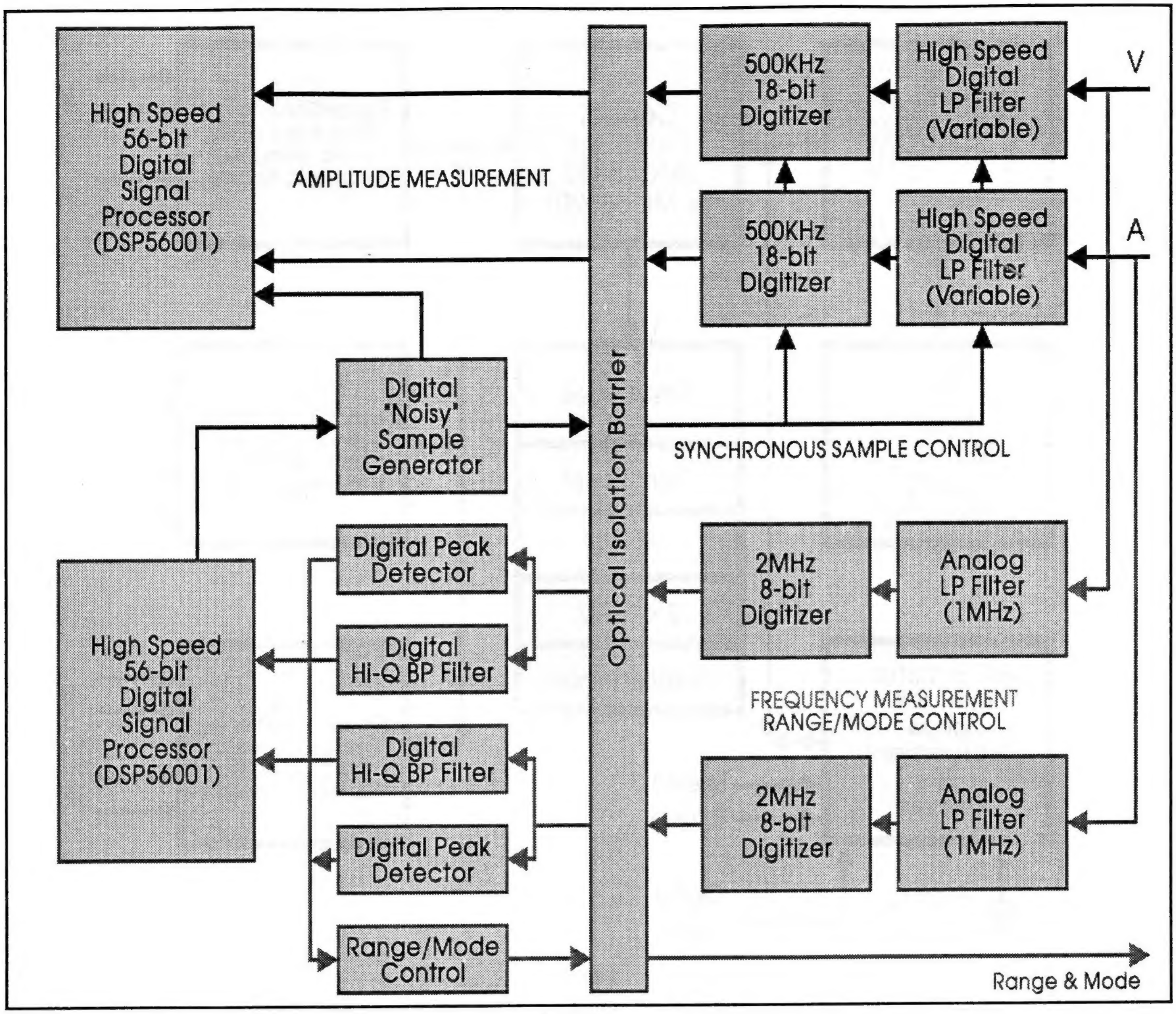


Fig. 2

2503AH Channel Block Diagram

The individual measurement and analysis functions of each channel include signal conditioning, data sampling, and analysis functions.

Each channel has dual high speed DSP's to measure frequency, set sampling rates, and perform a Fast Fourier Transform (FFT) implementation of the Discrete Fourier Transform (DFT).

Optocouplers and isolated supplies provide full galvanic isolation.

Individual Channel Functions

As mentioned in the previous section, individual channels pretty much constitute an independent power analyzer, which operates under control of the Central Processor. We will now review the most important building blocks of each channel. In the process, we will discuss many of the unique 2503AH operational features. The system architecture of 3 quasi independent analyzers, allows the user to optimize the analyzer's measurement configuration for the specific task at hand. The "Quick" start menus can be used as a starting point, with the operator further refining the instrument's setup as desired.

The Channel Input Section

Digital power analyzers have an input section which scales the analog input signals (voltage & current) so that these signals can later be converted to digital data format. The A/D conversion is generally performed by a chip which has a typical input range of 1 - 3 volts. The current and voltage inputs signals need to be "normalized" for the specific A/D chip, before they can be converted. In the 2503AH analyzers, high performance 18 bit A/D's are used. These chips have an input range of +/- 2.75 volts. So, the voltage inputs need to be attenuated, and the signals from the internal shunts need to be amplified to fit this input range.

In order to address the many and diverse power analysis applications, the analyzer must have a wide current and voltage input range. Input signals can vary from 12 Vdc to values in the kilovolt range, and current may range from a few milli-Amps to hundreds or even thousands of Amps. The input section has precision attenuators to scale the voltage down to the level that is required in the A/D section. The max. input voltage is 1200 Vrms, or 3000 Vpeak. With its large dynamic range, the analyzer can accurately measure signals with an amplitude up to 2.5 times the full scale value. Thus the Crest Factor (CF) is 2.5 at full scale, and even signals with peaks up to 2.5 times the input range can be accurately analyzed. The ranging is selected in Vrms, but the instrument actually detects peak input voltages, and then selects the appropriate measurement range. The ranging is done on the basis of the very fast 8 bit A/D output. The 8 bit A/D's operate at 2 MHz (yielding a sample every 0.5 micro-sec), thus the analyzer can range in milli-seconds.

The input signal conditioning is omitted from Fig. 2 in order to prevent the diagram from becoming too complicated. Fig. 3 shows the various inputs in more detail. Also, appendix A includes block schematics for each of the PCB's used in the 2503AH family, which may be reviewed for more detail. Current input signals can be measured via the voltage drop across internal shunt(s), or can be in the form of a voltage drop across an external shunt. When using internal shunts, the voltage drop is limited to a maximum of several hundred millivolts. The 2503AH has a high sensitivity 50 mA range on the one side, while also being able to measure up to 50 A peak (20 Amp rms) via the built-in shunts. For high power applications, the "Bypass" input can be used to measure currents of any magnitude by using external shunts or current transformers. Also, the internal HALL effect sensor can be used to measure currents up to 100 Amp peak (40 Amp rms). When using the Bypass mode, the user must specify the transducer scale factors. This scale factor is entered via the front panel, permitting the analyzer to display the proper current values. For example, a 0.003 Ohm external shunt will generate 3 mV per Amp of current. Hence the input scaling needs to be setup accordingly.

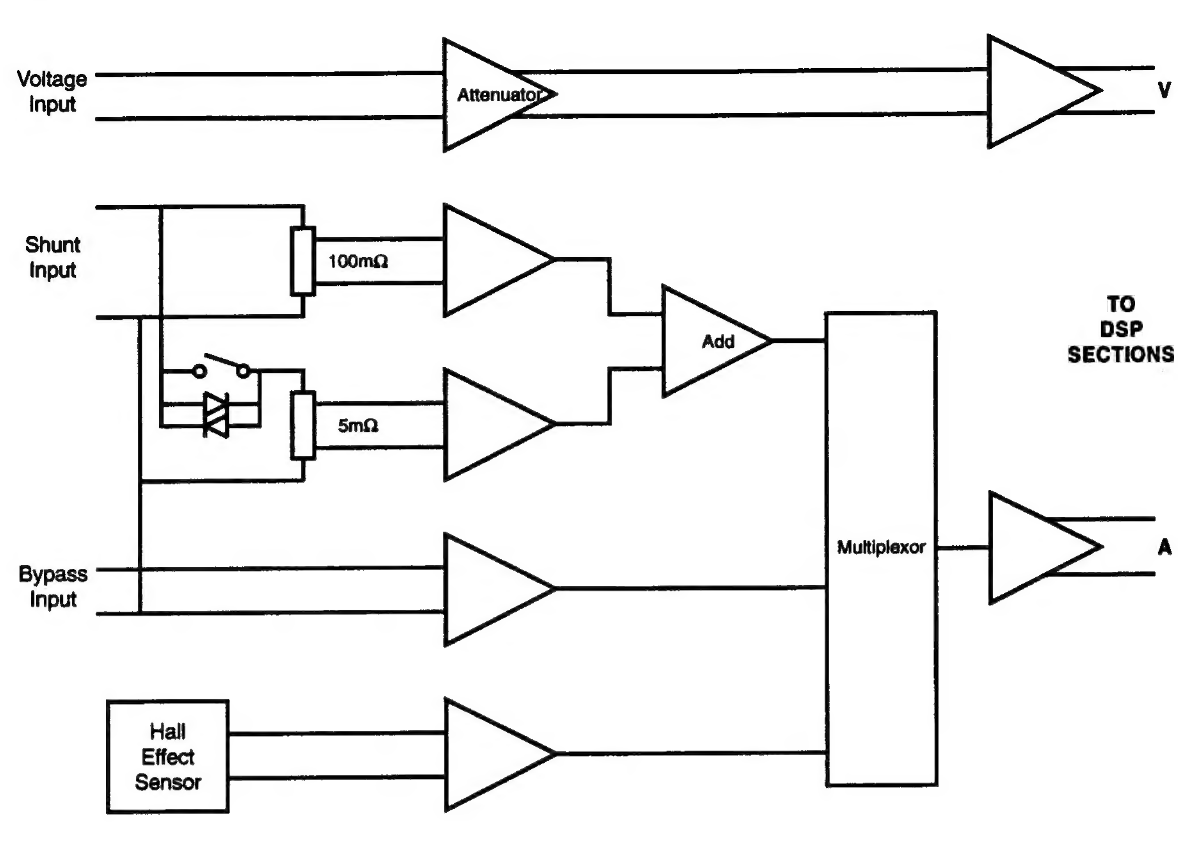


Fig. 3

Dual Shunt Current Input

The 2503AH has a unique dual shunt design for measuring current. Older designs typically employ only a single shunt, which has significant drawbacks as we can illustrate with a simple example. Let's assume that we have to analyze input power and harmonics on a 400 Hz, 1200 VA UPS system (see Fig. 4). We need to establish no-load standby power, full load power, and PF as well as harmonic distortion for both line voltage and current (to the 50 th harmonic) under all conditions. Generally, we are interested in harmonics down to levels of 1 % of the fundamental input voltage and current.

Under no-load condition, the input line current to the UPS is very low, say 100 mA. Under full load on the other hand, the line current may be high, say 12 A rms. Inrush currents as the line voltage returns after an interruption could be as high as 40 Amp peak. In order to measure the higher currents, we need a low impedance shunt. In the case of the 2503AH, this shunt is 5 milli-Ohm. A current of 12 A rms causes a voltage drop of 60 mV rms across this shunt. This 60 mV signal needs to be amplified to the appropriate level, before it can be converted in the (18 bit) A/D converter. The 60 mV signal however, also contains all the harmonic signal content, and a 1 % harmonic therefore could have a level of around 60 micro-volt !

It will be clear that the input circuit has to be designed with care, to make sure that the analyzer's own noise (from digital circuits, power supply etc.) is well below the smallest signal level. Since we are interested in harmonics up to 20 KHz (50 x 400 Hz) the gain-bandwidth product for the current input is demanding, but well within reach. Hence, both a single and dual shunt analyzer can provide good results for higher current applications.

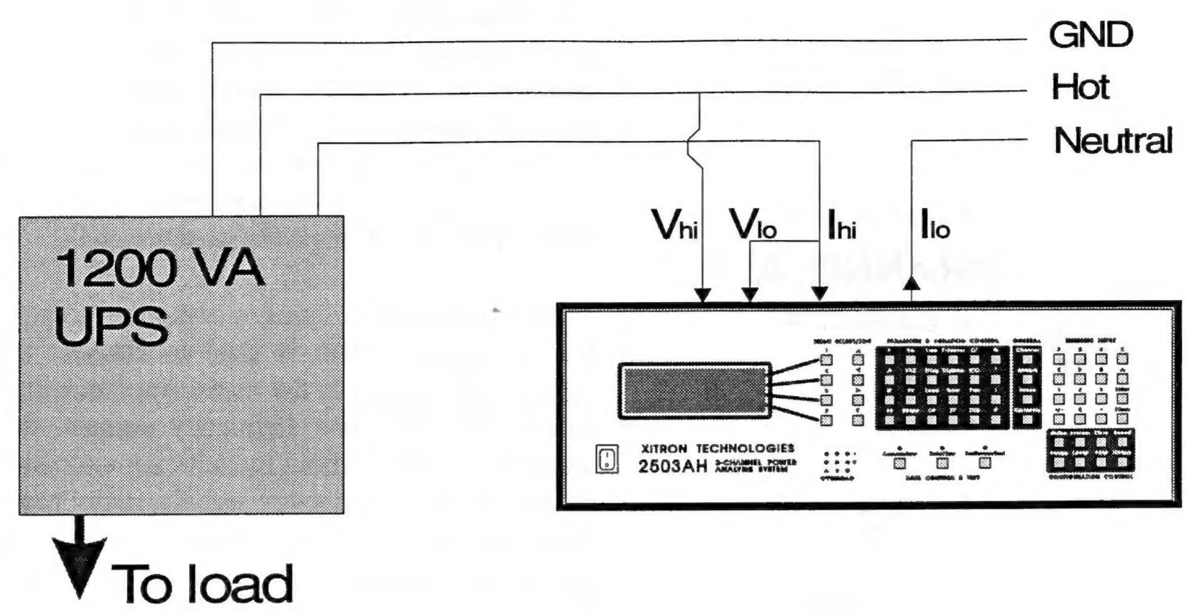


Fig. 4

The no-load 100 mA condition represents a formidable challenge for single shunt designs however. As you can see, a 100 mA signal only generates 0.5 mV across a 5 milli-Ohm shunt ! So, harmonic signals may be as small as 0.5 micro-volt ! Given the fact that the 0.5 mV signal needs to be amplified by a factor of at least 2000, it's obvious that it becomes virtually impossible to keep circuit noise low. Older, single shunt power analyzers "mask" the presence of this noise in their circuits, by displaying heavily filtered or averaged current readings. Whereas this results in "steady" readings, it obviously makes the instrument very slow. In fact, true current variations may indeed go unnoticed, because of the heavy filtering in these older designs.

A far better approach is to use dual shunts as shown in Fig. 3. In this case, the second 100 milli-Ohm shunt is used for low current level analysis. At 100 mA, the voltage drop across this shunt is 10 mV, which is a lot easier to handle than the above 0.5 mV. The dual shunt design therefore yields superior results in low power applications. There are many applications where both high (normal) and low load (standby) situations need to be analyzed. They include electronic ballasts, laser printers, FAX machines, copiers, video display monitors, laptop computers, automated lighting systems, electrical vehicles, elevators, etc.

The HALL Effect CT

In some cases, the internal shunt represents a undesirable burden. In these applications, the HALL effect sensor may be utilized to measure current. The HALL effect sensor provides good accuracy for signals up to 100 KHz. The sensor is configured for measurements from 1 - 40 Amp rms. If you wish to measure smaller currents, use multiple turns, and set the scale factor accordingly. For example, assume you want to measure a lamp current of 200 mA, in an electronic ballast application. In this case, loop the wire 5 times through the HALL effect sensor, set the CT scale factor to 0.2, and the analyzer will accurately measure the lamp current.

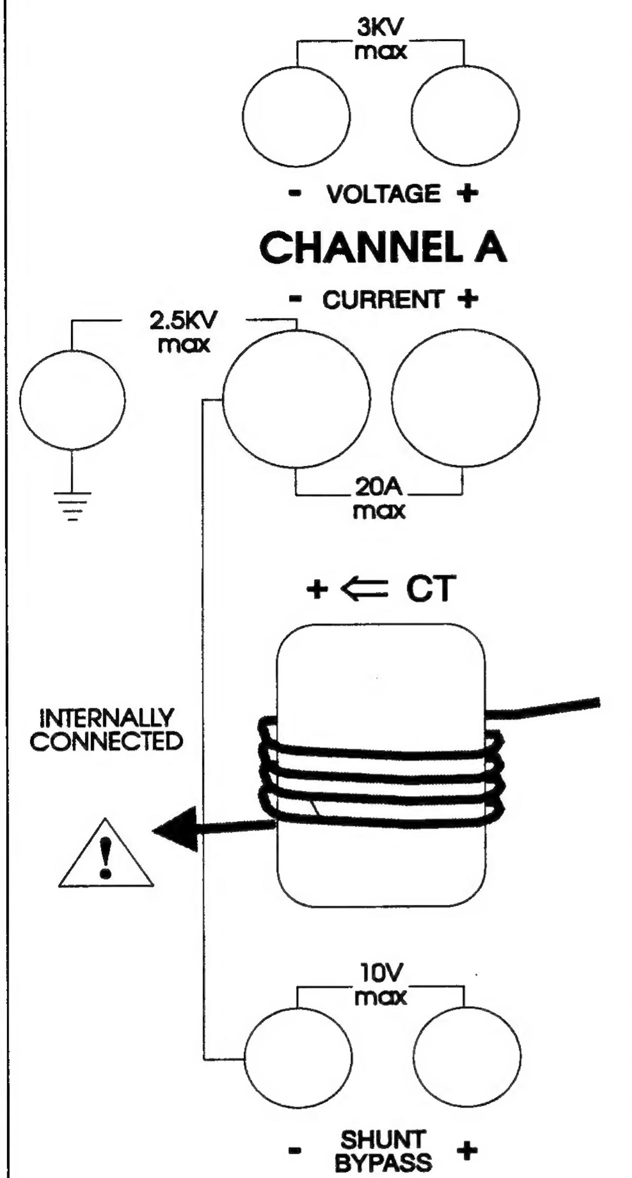


Fig. 5

External current transformers (CT's) or potential transformers (PT's) may be used in high power applications, or in applications where the analyzer input circuitry would represent an undesirable burden. In automated electronic ballast testing for example, it is necessary to use CT's to achieve acceptable measurements/analysis of high frequency signals.

In automated test systems, a computer controlled switching system is used to connect the appropriate signals to the measuring/analyzing instruments. For low frequency signals, this generally works without introducing excessive errors. For high frequency signals, many problems can occur. For electronic ballasts with typical signal frequencies from 20 -- 80 KHz , the combined capacitance and inductance of the cabling and signal switching system, cause the ballast loading to be significantly different from its "normal" lamp load. A solution is to keep the ballast's wiring as short as possible, and pick up the high frequency current with CT's. The CT output can then be routed via the computer controlled switching system without any problems. In this case, the Bypass input is used, and the user enters the scale factor for the particular CT model.

Also, high power levels generally require CT's, and may also necessitate PT's. High current levels in excess of 50 Amp, make external shunts or CT's mandatory. Not only is it impractical to equip the analyzer with terminals capable of such high currents, the internal shunts and wiring would have to be equally suited. External shunt values in the low milli-Ohm range are necessary for high current measurements.

When using CT's, it is important to notice the CT's output impedance. Some CT's have a high output impedance, which may require the scale factor to be adjusted, in order to compensate for signal losses. Contact Xitron if you have any doubts regarding the suitability of specific CT types for your analysis task.

Input isolation

Many applications require that the input and A/D circuits of each channel are isolated from other channels, as well as from the rest of the instrument. For example, in electronic ballasts the lamp power is isolated from the input power (110 / 220 Vac). In three phase delta connections, both voltage input terminals and both current input terminals are at high voltage levels. In electrical

vehicles, one channel may be used to measure low voltage DC (battery) signals, while the other channel(s) are used to measure high voltage (3 phase motor) signals.

The input channels are isolated via individual isolated supplies. The system power supply provides 5 Volt to each channel. This 5 V is then converted by DC-DC converters to +/- 15 Volt and 5 V for each channel. The DC-DC converters are specially designed for power analysis and similar high voltage applications, and they are rated for 3 KV. The A/D converter circuit is also isolated via these DC-DC converters. After the input signals are converted, they are transferred to the analysis section via opto-couplers. The analysis section therefore doesn't have to be isolated, and operates directly from the 5 V Dc supplied by the system power supply.

Input protection

The voltage input is inherently protected. It's high input impedance (600 KOhm) limits the current flow. The more vulnerable input is the Bypass circuit. If the user accidentally mixes up the input wiring, and applies line voltage across the Bypass input, it can be damaged. Even the internal shunt may be damaged if applying line voltage in a full short circuit across the shunt. By its very nature, the shunt has a very low impedance. Even though (see Fig. 3) the 5 milli-Ohm shunt becomes active as soon as the voltage across the 100 milli-Ohm shunt exceeds the forward voltage drop across the diodes, the line voltage circuit breakers are rather slow, and may not activate before the shunt has overheated. Full short circuit currents of 150 Amp and higher have been observed, before the braker reacts.

Some analyzers utilize an internal fast fuse to protect the shunt. This technique certainly works for line voltage type applications, where signals with a maximum frequencies of say 2 KHz are considered. For high frequency (small amplitude) signals, such as found in many electronic ballasts and motor control circuits, the use of an internal fuse results in unwanted signal errors. If so desired, an external (fast) 25 Amp fuse may be used in line with the measurement circuit. It should be noted however, that the external fuse will have the same detrimental effect on frequency response.

For high frequency (500 KHz) power analysis, even the smallest parasitic inductance in the input circuit can result in significant measurement errors. Provided the user doesn't short circuit line voltage via the shunt, the input configuration of the 2503AH is the best compromise between frequency response, and reasonable protection. The 2503AH's internal shunts can handle short duration, high peak currents very well. In fact, over the course of approximately 1 million operating hours, only 4 shunts were damaged by excessive currents.

Measurement Reference Point Considerations

As discussed above, the 2503AH inputs are isolated, or floating. Nevertheless, every measurement system must have a reference point. In the case of the 2503AH family, the reference point is the "Current Low" terminal. Thus, both the Voltage High and Voltage Low terminals have an impedance of 600 KOhm with respect to the Current Low terminal.

When current measurements are made by using an isolated CT, the Current Low terminal essentially "floats" because the CT's output floats. Even though the analyzer has superb common mode rejection, and the highest dynamic range available on the market, it is advisable to ground the Current Low terminal when using floating CT's. The ground terminal is located next to the Current Low terminal for this reason. Notice that each channel is individually isolated, hence this ground connection can be made on a channel by channel basis.

Amplitude Measurement Circuitry and DSP

Each input, after scaling, is filtered by a high speed digital low-pass filter having its corner frequency (filter clock frequency) controlled by one of three filter clocks common to all amplitude systems. After filtering, each input signal is then converted to 18-bit digital form by an 18-bit analog-to-digital converter system, whose sample clock is taken from one of three sample clocks common to all amplitude systems. Each converter is actually consists of a pair of time interleaved 250 KHz converters, allowing for sampling at up to 500KHz (see Fig. 2 for the channel block diagram).

The output of all four converters (two per input) is read by a Motorola DSP56001, at a rate controlled by the same sample clock used by the converters. This processor performs all amplitude and harmonic analysis required by the system, and maintains a database of the results of the latest such measurements for its channel. The central processor gains access to these results via a high speed RS485 data link. This same link is used to pass to the DSP the selections to use for its sample and filter clock signals, and details regarding the measurements to be made. The channel Pcb with this harmonic analysis DSP is internally named the "Amplitude DSP".

Frequency Measurement, Range/Mode Control, Sample Generation & DSP

As well as being passed to the amplitude measurement system, each scaled input is also passed to a second sub-system for additional analysis. This second sub-system is internally named the "Supervisor DSP" Pcb, and consists of the following portions ;

Filter and High Speed ADC

Each input is passed through an analog 1MHz low pass filter, and sampled at 2MHz by a pair of 8-bit analog-to-digital converters.

Supervisory Processor

The outputs of the pair of 8-bit converters is read by a Motorola DSP56001, which performs several asynchronous tasks using this data. This processor is linked to the central processor using the high speed RS485 data link.

Overload and Underload Detection.

Each sample is checked for overload status, if an overload is detected then the DSP changes the range (if able) presented to the input scaling circuitry, and informs the central processor that a range change has occurred. If an underload condition remains for longer than a period provided by the central processor (actually set by the minimum fundamental frequency expected) then the DSP changes the range (if able) presented to the input scaling circuitry, and informs the central processor that a range change has occurred. This process is continuous, independent between the inputs, and completely independent of any other activities in progress in the instrument. The user may also set a fixed range, rather than the above autorange process.

Bandpass Filtering and Frequency Measurement.

Input samples are passed through a proprietary system which performs a tracking bandpass filter function, maintaining track of the fundamental frequency component in the range provided by the central processor (set by the user specified fundamental frequency range), which is then used to measure the frequency of this remaining signal component. This process is continuous, independent between the inputs, and completely independent of any other activities in progress either in the instrument, or by the supervisory processor.

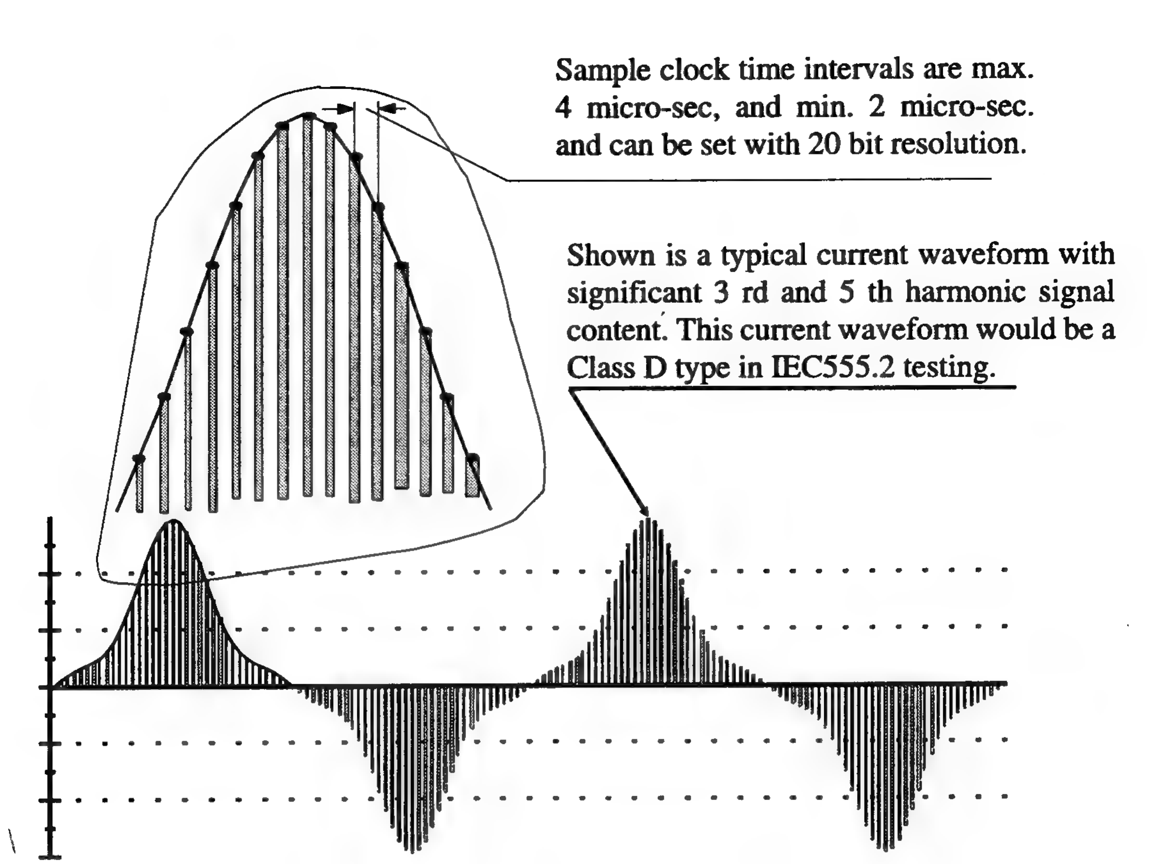


Fig. 6

Sample Clock Generation.

Under the direction of the central processor, the supervisory DSP controls circuitry contained in an ASIC which generates a digital clock signal whose average frequency is settable with 20-bit resolution over a 2:1 range of frequencies. This clock signal is available to all amplitude DSP systems on one of three such signal lines. If desired by the central processor, the supervisory processor can "link" this frequency to that of either of its measured input frequencies. The form of the sample clock is such that the individual sample-to-sample clock period can vary by up to 1%, but the average over any 256 sample period is always within 1ppm of the set value. This "jittered" sampling (also called "dithering") prevents so called aliasing of high frequency signals.

Without this jittered sampling, frequency components in excess of the 500 KHz max. sampling rate could 'fold back" into the analysis range. Analyzers without this enhanced sampling technique need to implement anti-aliasing low-pass filters. These filters cause amplitude ripple and/or phase errors in the frequency range of interest however. In the 400 - 500 KHz range, anti-aliasing filters could cause amplitude errors in the 5 - 10 % range, and phase errors in excess of 45^{0} ! The jittered sampling also guarantees optimum crest factor measurements, because it has the same results as if the sampling rate would be an order of magnitude higher than (the already respectable) 500 KHz.

Filter Clock Generation.

Under the direction of the central processor, the supervisory DSP controls circuitry contained in an ASIC which generates a digital clock signal whose frequency is selectable in 1.2:1 steps over 4.5 decades of frequencies. This clock signal is available to all amplitude DSP systems on one of three such signal lines.

User Selectable System & Channel Functions

As follows from the preceding review of operational concepts, the user can control a number of functions and capabilities on a channel by channel basis. In addition, the user may control a variety of overall system functions. We will first review the system functions and then discuss the setup flexibility of individual channels. The menu trees shown in Fig. 7 - 12 illustrate the various menus which can be used to access the functions which are under the user's control.

System Menu

Overall system functions can be controlled through the "System" menu. This menu is activated by pressing the "System" button (CONFIGURATION CONTROL field).

The "SYSTEM CONFIGURATION" message will show on the first display line. The following lines will display the various items as shown in Fig. 7. Use the "up" and "down" arrow keys to scroll through the complete list. Note that some items are optional, and they will not appear if not installed. Configuration items may be accessed by pressing the display line button next to the menu choice.

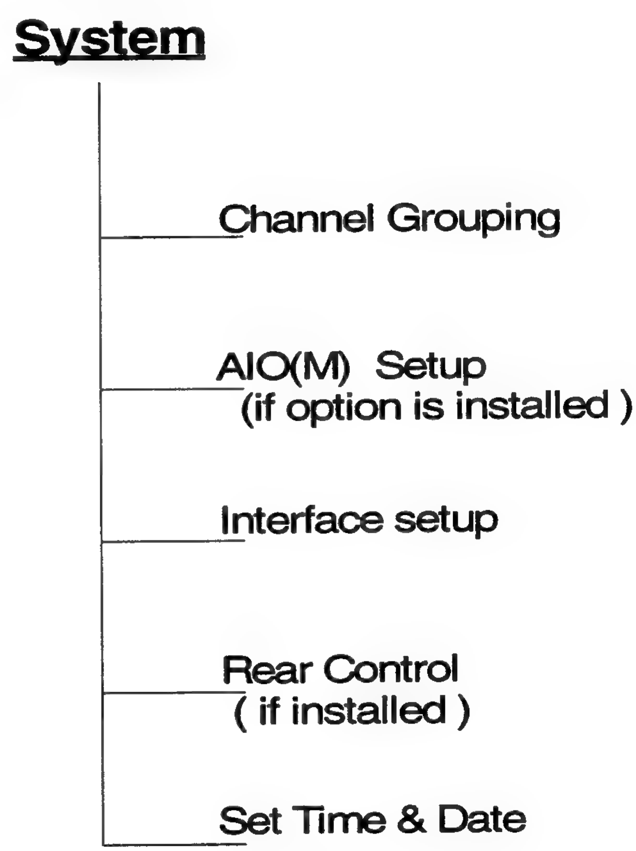


Fig. 7

Interface menu

For example, the Interfaces can be set up by pressing the button next to the word "Interface". When a menu item is activated by pressing the button next to it, a second menu pops up. This second menu allows the individual settings to be modified. This type of user interface is consistently used throughout the analyzer's operation. To select or modify a particular item, press the button next to it. If a line consists of multiple parameters that can be modified, a blinking cursor will appear over the first item. The left and right arrow keys then permit the cursor to be moved to other items on the same line.

To illustrate how this works, select the Interface item from the System menu. The Interface menu, which is shown in Fig. 8 permits the user to change the IEEE-488 interface address, and turn the port on or off. If any selection is changed, the "Enter" key needs to be pressed to confirm the change, and then the next item can be selected. To return to the normal parameter display, the user simply needs to press the Enter key again.

The two RS232 ports can also be controlled via the same Interface menu. The Baud-rate can be set from 1200 - 48,400 Baud. To change this setting, activate the appropriate line, and observe the blinking cursor (default is 9600).

Press the up-or-down arrow keys to change the setting. When done, press the right hand arrow key to move the cursor to the next field. Now use the up or down arrow to change the setting to "control", "printer", "monitor", or to "off". When done press the Enter key to confirm the selection, and then press the Enter key again to return to the normal display.

The parallel printer port can be controlled in a similar fashion by selecting the parallel printer line.

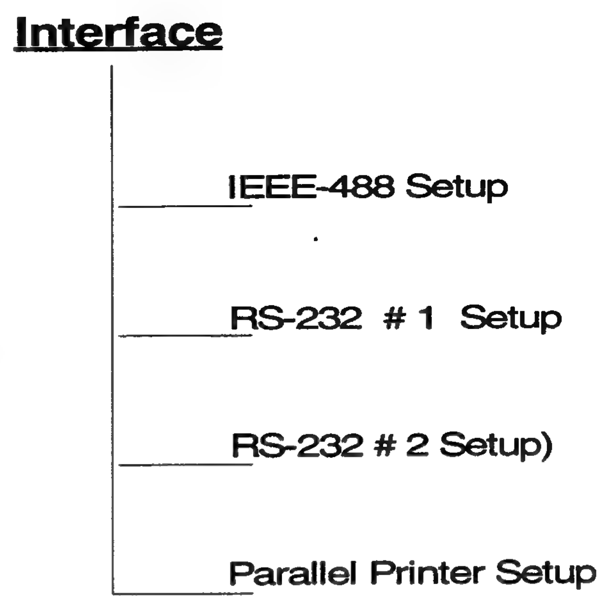


Fig. 8

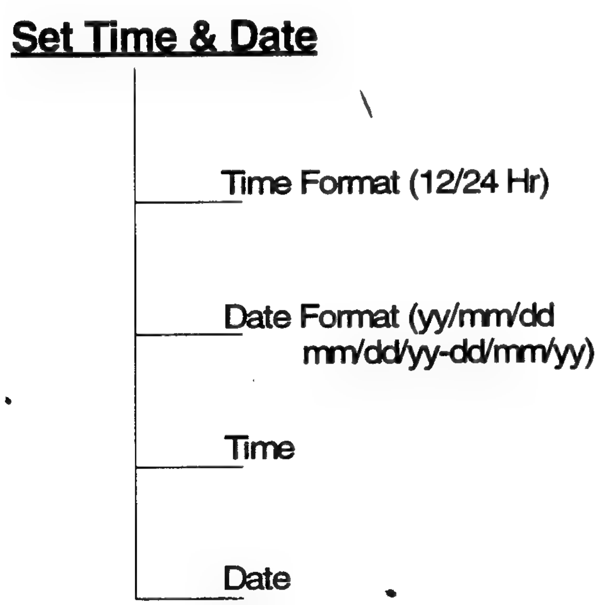


Fig. 9

Time & Date Menu

The time & date menu can be accessed via the System menu, as shown in Fig. 7. The user may set the format, and enter the actual time and date for the particular time zone. The four selections you can address are shown in Fig. 9.

To change the time format, press the button next to the Time Format line (no. 1 button). Since the time format has only two choices, pushing the button will automatically toggle between the 12 and 24 hour display format.

This direct toggle method is also used in other instances where only two choices are given. The Date Format line has three different selections, so in this case the up or down arrows are used to select the proper choice. In this case, the line is first activated by pushing the button next to it. The cursor will blink in the right-most field on the line. By pressing the up or down arrow, the display will step through the three different date formats. Note that the date display on the fourth display line will automatically follow the format which is active at the time. In fact, the time display also changes to follow the active format shown on the first display line.

Note that the date and time can be read via the GPIB (IEEE-4888) and serial ports, for the purpose of time stamping any computer collected data.

The Advanced Setup Menu

The Advanced setup menu provides access to all the 2503AH analyzer's flexibility. ***The Standard Setup is a subset of the Advanced Setup. Therefore, the Standard Setup menu is not separately covered.***

To access the Advanced Setup menu, first select the System menu and then select the Channel Grouping line. The display will look like the one shown in Fig. 10B.

The advanced setup applies to individual channels, hence the channel needs to be selected. As discussed in the Operational Concepts section, a 2503AH really consists of 3 individual analyzers, which can operate independently or may be linked together as a three phase instrument. Channels can be defined as Input, Output or Aux. Also, each channel may be defined as part of a 3 phase setup, or as an independent "group". This means that Ch-A and Ch-B could be set to operate as a 2 Wattmeter instrument in a 60 Hz, 3 phase-3 wire configuration, with Ch-C operating by itself on a 400 Hz line.

So, in order to access all the advanced capabilities, select the appropriate channel line, and then move the cursor to the "more" field. The top display line will show the current setup.

Pressing the top display line key repeatedly, will step the analyzer through the setup possibilities for the particular channel. When the top line shows that the Advanced Setup is active, the user may modify all the functions shown in Fig.10A. The individual items can be accessed by scrolling the display up/down as explained before. The individual items are as follows:

Advanced Setup

- Fund: Sync Frequency
  Sync x XXXXXXX (ratio)
  Fixed (enter frequency)
- Sync: Low - High frequency limits
  for the synchronization range
- From: Synchronization source
  i.e. ChA V only, ChA I only etc.
- Min. Period: The minimum measurement
  period in seconds.
- Filter: The low pass filter frequency
  which is applied to input signals
- Analysis: Simple, Averaged, IEC555
  or no analysis.
- Check Source Valid: Yes or No
- Sync Averaging: Med/fast/slow or none.
- Sync. Period: Synchronization period in sec.

Fig . 10A

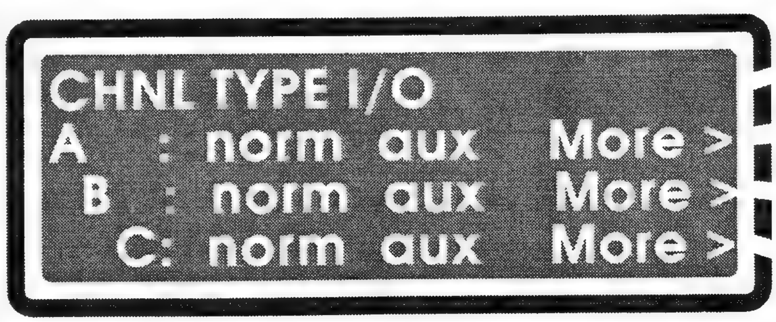


Fig. 10B

Measurement Synchronization:

The **Fund:** line determines the measurement synchronization, and can be set to three possible choices. The first and most common choice, is to set the synchronization to the fundamental frequency (**Sync Frequency**). This directs the channel Supervisor circuitry to measure the fundamental frequency of the input signal, and then synchronize the sampling rate to this frequency. The Supervisor will search for the fundamental frequency in the range specified on the next line. For a line frequency measurement, the "Sync:" line would be set from 40 - 70 Hz, as this covers both 50 Hz and 60 Hz applications.

If measurements are to be made on the lamp side of a high frequency electronic ballast, the "**Sync:**" range could be set from 5 -- 200 KHz as this covers every electronic ballast manufactured today. The analyzer has a built-in "Quick" setup to configure the instrument for ballast measurements. The use of Quick menus will be discussed in more detail in the next section. The user may also enter a ***Fixed frequency***. This is particularly applicable for inrush measurements. The analyzer can be pre-synchronized to 60 (50) Hz by fixing the sysnchronization frequency to 60.000 (50) Hz. Also, in cases of heavily distorted line signals, or modulation frequencies very close to the fundamental frequency, a fixed synchronization can help getting better measurements.

The third item to determine for synchronization purposes, is the sync source (**From:**). As explained earlier, each channel can be synchronized to itself, or to other channels. The "From:" line allows the user to define where the subject channel gets its synchronization from. Normally, for Ch-A,the sync. source would be Ch-A V or I. With this setting, the Supervisory will automatically select the most stable sync. source. For some applications, V only or I only will produce better results. For example, a motor drive circuit (with PWM control) will give better results with "I only" as the current will be "filtered" by the motor.

For some applications, synchronizing to another channel may be necessary. For example, a HF electronic ballast efficiency measurement will produce optimum results when synchronizing the sampling rate on the line and HF side. So, the HF channel(s) B (and C) could be configured to obtain their synchronization from Ch-A. This will guarantee that samples on both sides are perfectly synchronous. Yet, to optimize for CF measurements on the HF side, it is better to let Ch-B (and C) be synchronized to the high frequency.

Min Period: determines the minimum measurement period over which the analyzer will calculate the various parameters. The smallest period you may set, is one cycle period or 1 ms. whichever is bigger. If the above sync. range is set from 40 - 70 Hz, the minimum time is the period of 40 Hz, or 0.025 s.

Filter: determines the corner frequency of the low pass filter which the input signals are passed through. The highest value the filter may be set to is 5,000 KHz (5 MHz). The lowest value the instrument will accept is the the upper sync. range. In order to maintain high accuracy amplitude readings, the low pass filter should be set to at least 2 - 3 times the highest frequency of interest. The amplitude accuracy will be within 1 % for frequencies below **0.8 x Filter frequency .**

Analysis: determines the type of analysis being performed. The choices are to perform a simple FFT (this is the fastest analysis type), an averaged FFT, a IEC555.2 compliant FFT (over a sample size of 16 cycles of 50 Hz i.e. 320 ms) , or to turn analysis off (none). The line below the **Analysis:**

line will vary, depending on the selected analysis type. In the case of IEC555.2 analysis, the user can select to have Source Checking performed, or to ignore the source quality.

IEC555.2 (also known as IEC1000-3-2 or EN-61000-3-2) requires a high quality power source for harmonic current analysis purposes. Irrespective of how bad the unit under test behaves, the power source has to maintain the supply voltage within 2 % of the nominal level, and voltage harmonic distortion has to be minimal. In addition, the frequency has to be stable, phase accuracy for 3 phase systems has to be maintained within +/- 1.5 °, and the voltage Crest Factor has to be maintained within a range of 1.40 - 1.42 . It should be noted that these values apply while the measurements are being made. When performing verification of IEC555.2 compliance therefore, Source Checking should be turned on. Actually, one could even contend that continuous Source Checking is mandatory to certify compliance.

IEC555.2 Source Checking

Voltage accuracy/stability: +/- 2 % of nominal
Frequency stability: +/- 0.5 % of nominal
Phase accuracy (3 ph. only): +/- 1.5 ° of 120 °
Crest Factor: 1.40 - 1.42 and peak shall occur between 87 - 93 ° after zero crossing

Max. harmonic voltages (during the test)
3 rd harmonic : 0.9 %
5 th harmonic : 0.4 %
7 th harmonic : 0.3 %
9 th harmonic : 0.2 %
Even harmonics from 2 - 10 : 0.2 %
All harmonics from 11 - 40 : 0.1 %

Fig. 11

On the other hand, for engineering evaluations, a user may operate the test with 230 Vac line voltage and the Source Checking turned off. This will permit analysis without having to have access to an expensive source.

If the analysis type is any choice other than IEC555.2 , the Source Checking line will not appear. For simple and averaged analysis types, two additional display items will appear. The **Max. Harmonics:** permits the user to define the highest harmonic he is interested in. The instrument will default to 49, but the user may select up to the 1000 th. harmonic. The **Fundamental : BW:** line gives the user control over the individual "bin width" of the FFT. In software versions 3.0 and higher, this line is now called **Number of Cycles** , and the user can control the sampling resolution by selecting the number of cycles. If a number of 16 cycles is entered, the analyzer will set its data acquisition such that the data samples are obtained over a total of 16 cycles of the fundamental frequency. The max. number of samples remains 8192, but could be less. Given that the highest sampling rate is 500 KHz, the 8192 samples can be maintained up to about 61 Hz. for higher fundamental frequencies, the number of samples will be smaller.

FFT Type: determines the windowing method being used. The choices are Normal, meaning a rectangular window, or Windowed. When Windowed is selected, a modified Blackman-Harris windowing function is applied. In IEC555.2 analysis mode, the rectangular window, with no-overlap/no-gaps is required.

Sync Averaging: permits the user to select no, slow, medium or fast averaging of the frequency measurement. In case of varying fundamental frequencies, the results may be averaged over 2 measurements (fast), 4 measurements (med) or 8 measurements (slow).

Sync Period: determines the period over which the sync. signal is evaluated. Note that this is just for the frequency measurement, and has no relation to the measurement period for amplitude or harmonic analysis.

Setting up Input Scaling

The inputs for the 2503AH normally operate in autorange mode. The user may manually change ranges, select the internal shunts, bypass inputs, or the HALL effect CT. Also, scale factors can be entered to accommodate any external shunt, CT, or PT.

The **Range** button (CONFIGURATION CONTROL field) provides access to the SET RANGES menu. Fig. 12 shows the displays giving access to the instrument's ranging. The first display is called up by pushing the Range button. The ranging actually consists of more items than fit on one screen, and the second figure shows the bottom 3 lines of the display. The down arrow key is used to scroll down to these additional display lines.

The third display can be accessed by selecting the Setup Input Scaling line. The input scaling works similar to other menus. A given line is selected by pushing the button associated with that line. A flashing cursor will appear on the selected line, and then individual items may be modified. In the case of the input ranges, the appropriate channel (A, B or C) needs to be selected. A flashing cursor will indicate which item can be modified. With the cursor in the "autoV" field, the range may be modified by pushing the up-or-down arrows. Then the left-right arrows may be used to move the cursor to adjacent items. Again, the up-down arrows permit the particular field to be modified. In the case of the current measurement, the user may pick Shunt, Bypass or Hall. When selecting Bypass, a scale factor needs to be entered. This can be done by returning (pressing the Enter key) to the display that gives access to the line showing Setup Input Scaling. Like other selections, the Input Scaling can be set for Ch-A, Ch-B or Ch-C. The user may select the channel on the top line.

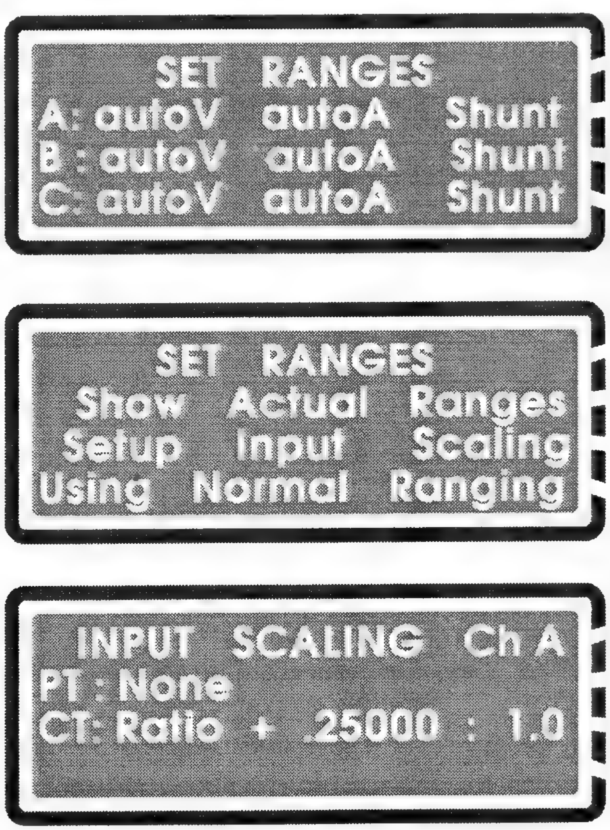


Fig. 12

The Hall effect CT input can be configured for multiple turns (for higher sensitivity). The last display shows the setting for 4 turns through the CT.

The active ranges for all three channels may be shown by pressing the button next to the line with Show Actual Ranges. The instrument will normally be used in autoranging mode, except for inrush current/voltage measurements, or for cases where fluctuating levels have to be measured (such as IEC555.2 Fluctuating tests). In these cases, one wants to "freeze" the range to prevent the instrument from autoranging up-or-down.

Even though the user may have selected a fixed range, the instrument will still range up if its input is overloaded by more than 250 %. The user may change to "Strict Ranging" by pushing the button next to the "Using Normal Ranging" line. With Strict Ranging, the analyzer will maintain the selected input range, even in overload conditions. If the instrument is reset, or is turned off and back on again, it will return to Normal Ranging.

Setting up Display Parameters and Storing Configurations

As discussed in earlier sections, individual channels can be configured for a particular measurement task. Channel A could be configured to do line measurements, while Channel B and C could be set up to perform high frequency signal analysis. The instrument has a number of factory programmed **Quick** Configurations, which are very convenient. The user may use **Advanced Setup** to modify the factory defaults, or build a totally new custom configuration, and **Store** this configuration in non-volatile memory.

Similarly, the user can define display parameters as desired. Each display line can be programmed to show a variety of measured/calculated parameters, or values calculated from a selected parameter in conjunction with a reference value. For example, the user may define a display line to show individual harmonic currents, or to show a given harmonic as a percent of the fundamental current. Similarly, a display line can be set up to display one of the many calculated parameters such as THD, PF, CF, FF, Watts, VA, Loss, Efficiency etc. Parameters may be mixed and matched between channels as desired. As an example, the first 3 lines could be setup to measure voltage in Ch-A,B,and C, while the next 3 lines could be defined to show the current for Ch-A,B, and C. The following set of 3 lines could display power for each channel etc. When the user stores a complete instrument configuration, the defined display lines are also stored. The user can then later **Recall** the complete instrument setup with the push of a few buttons. In addition, the user may give a meaningful **Name** to a stored setting, so it's easy to remember.

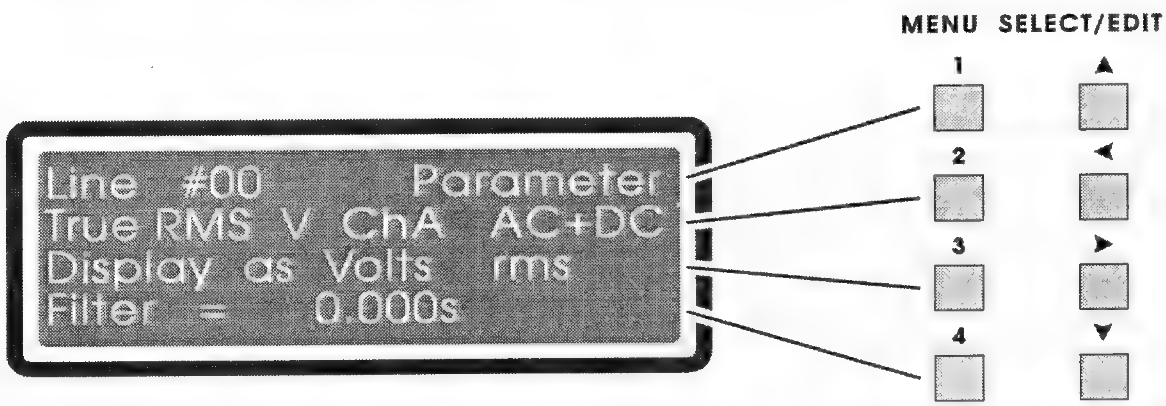


Fig. 13

To setup a display line, simply activate the line by pressing the button next to it. The display will look like the one shown in Fig. 13. Note that the line number "00" is the first display line. Every line has a more detailed setup "behind it" as is shown. In this case, the selected parameter is the RMS voltage of channel A. In this case, the signal coupling is selected to be AC+DC, the level will be displayed in Vrms, and the instantaneous level will be shown without any filtering/averaging.

If so desired, the user may select AC or DC coupling, the display can be in other units such as dB's, and the value may be averaged over a selectable period like 0.250 s. In the above example, the display units can be modified by pressing the "line no. 3" key, and then press the up/down arrows to step through the "units" choices. When done, press the "Enter" key, several times if necessary, and the instrument returns to the "normal" display. Every display line can be set up similarly.

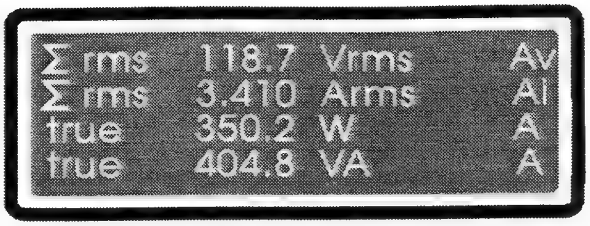


Fig. 14

Fig. 14 depicts a typical example of a display which is set up for voltage, current, power in Watts and VA's, for channel A. As mentioned earlier, the user can define up to 50 display lines and scroll the display up/down to review all the selected parameters. The front panel field PARAMETER & EQUATION CONTROL shows many of the parameters that can be displayed. a complete listing of parameters is given in a later section.

If a particular setup is to used repeatedly, it may be stored in non-volatile memory. This is easily accomplished by pressing the "Store" button, and then selecting a memory location. pressing the Store button brings up a display similar to the top-one shown in fig. 15. Notice that in the display, memory location "00000" is followed by an asterix. This asterix indicates that setting 00000 is currently active. The 250xAH analyzer family will always power up in the active setting.

The analyzer may store many complete instrument configurations. If all settings were very simple, it could in fact store 64K configurations, as this is the available non-volatile memory. Assigning a meaningful name to stored settings makes it easy to recall the correct setup later. In order to assign a name, the user must select the "Edit Directory" line, and then press the key associated with the line showing "Name". A flashing cursor will appear, indicating that the user may select the first character for the stored setting name. By pressing the up/down arrows, the user can step through the available character set. After selecting the character, press the right arrow key to move to the next character field, and repeat the process. Even though this naming process takes a little time, it's only done once for every stored setting.

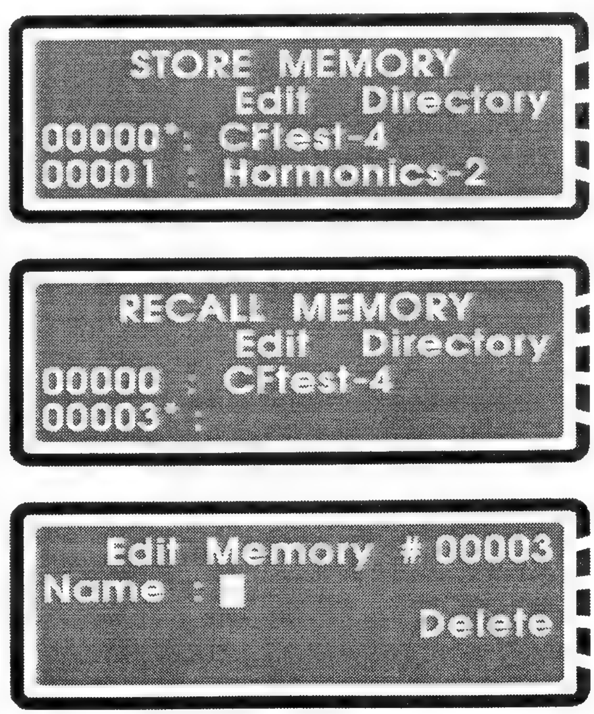


Fig. 15

Complete instrument configurations can be recalled by pressing the "Recall" button. The display will show the active setting, as well as the one following it. Use the up/down arrows to scroll through the list of available configurations. Pressing the button next to a given stored setting will recall this setting, and the instrument display will briefly show an appropriate message.

As is shown in the bottom display of Fig. 15, it's also possible to delete a stored setting. In addition, the user may edit a name as required. If a stored setting is modified, and then stored under a new number, the old name is copied along. Thus, the user needs to edit the name to reflect the changes in setup.

Note that stored settings can also be recalled by a computer via the IEEE-488 interface. This is the fastest way to reconfigure the analyzer is speed sensitive applications.

Displaying Harmonics & THD

Current and voltage harmonics can be displayed, just like other parameters. The user may also print out measurement data on a standard PC compatible printer (requires the INT option). The interface (INT) option also support serial (RS-232) printers and GPIB (IEEE-488) control.

Harmonics data can be displayed in several ways. The most popular way is to display harmonics in absolute numbers, i.e. Amps for current and Volts for voltage harmonics. Harmonics may also be displayed in dB's or percentages, however. Whereas one may select a display line to show harmonic distortion (THD) for all harmonics, it's also possible to display only a limited group of harmonics. So, a user may select to display the 3 - 9 th harmonic in percent of the overall RMS current. Because of demands from various application fields, one may even select from 3 different ways to display THD. The most common way is to display harmonic distortion as a percent of the fundamental waveform amplitude. This parameter is called THD-Fund. THD may also be shown as a percent of the total RMS level (THD-Sig) or as a percent of the harmonic content in the signal (THD-Harm).

Defining display lines for harmonic analysis is very simple. The user first selects the applicable display line by pressing the associated button. To select a line for current harmonics, the "**A**" button in the "PARAMETER & EQUATION CONTROL FIELD" is pressed. This causes the display line to be selected for overall (rms) current measurement. If voltage harmonics are to be displayed, the user first selects the " **V**" button. Next, the the "**Harmonic**" button in the front panel "GENERAL" field is pressed, in order to change the "AC+DC" field into the harmonics to be measured.

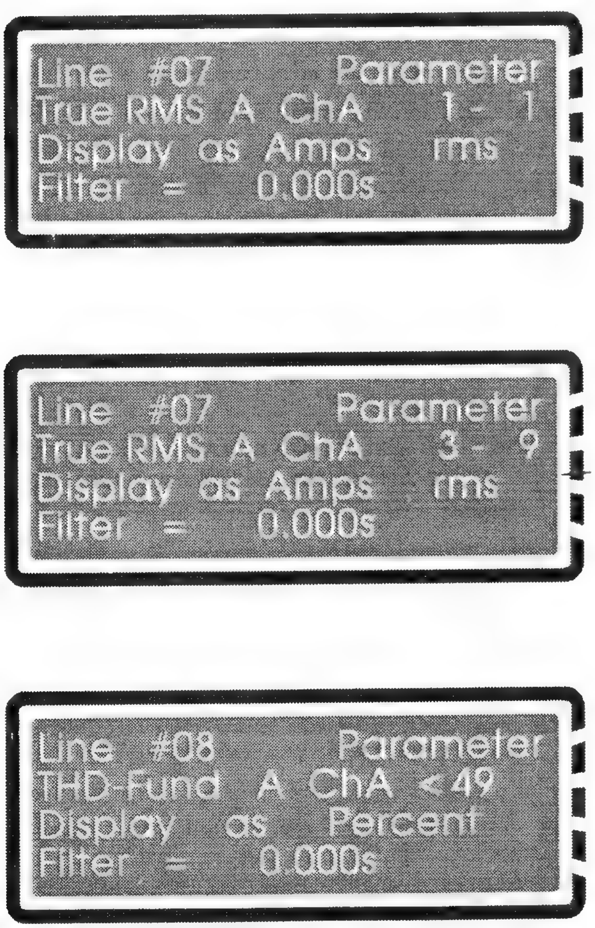


Fig. 16

The display will now show the starting-and-ending harmonic, for which the current or voltage level will be displayed (see Fig. 16). So, to display the fundamental, the starting-and-ending harmonic is "1" as shown in Fig. 16.

To display the level of harmonic content for a group of harmonics, i.e. from 3 - 9, the starting-and-ending number would be modified as required. First change the starting number, then press "Enter" to accept the value, next change the ending number and press "Enter" to accept the entry. Finally, press the "Enter" key again to return to the "normal" display. Multiple lines can be defined for individual harmonics.

Individual harmonics may also be displayed as a percent of another parameter. This can be achieved in the following fashion. First define a line as explained

above. Now press the line # 1 key repeatedly until it shows PARAM/REF (there are several related choices, so make sure you pick the right one). Next press the line #3 key, and use the up/down arrows to change this line from "Ref= " to read "Updated Ref. Param." and press the "Enter" key.

Next press the line # 4 key, and change this line to the parameter you wish to use as the reference. If the harmonic analysis is done for Ch-A, you would typically select "True RMS A ChA AC+DC" but it could also be another parameter. After selecting the appropriate parameter, press the "Enter" key to accept the choice.

There is one more item to be selected. The default is for harmonic levels to be displayed as a ratio of the selected reference. Often, it is important to display a harmonic as a percent of overall current. There is a fifth display line, which allows the display to be defined in either percentages, Ratio, Units, or dB's. Use the down arrow to scroll to this fifth display definition line, which allows you to change the display to be in percent of the selected reference. The final result is that the harmonic is displayed as a percent of the overall (rms) current. This procedure applies to individual voltage and current harmonics, as well as to a range of harmonics. Note that you may define another harmonic (i.e. the fundamental current) as the reference, thus displaying the harmonic as a ration or percentage of the fundamental current level. Fig. 17 shows the display along with the fifth definition line.

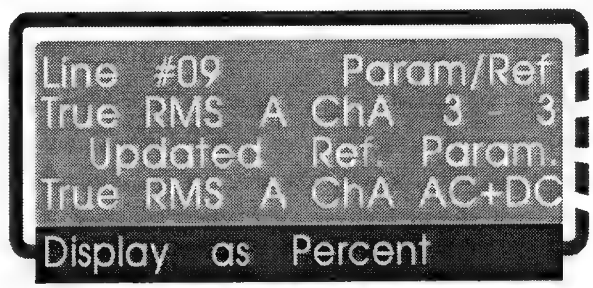


Fig. 17

THD can be displayed by selecting a given display line, and pressing the THD button. The up/down arrows may be used to select the desired THD type. The instrument will default to THD-Fund. With the cursor flashing over THD-Fund, the user may push the up arrow key to select either of the other THD parameters.

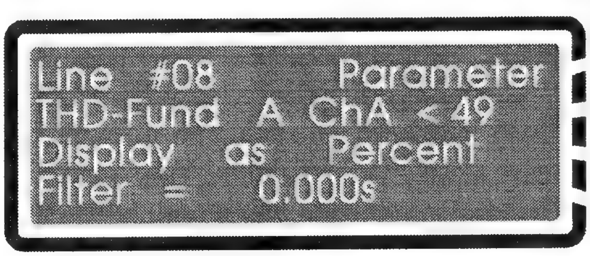


Fig. 18

Also the channel needs to be selected, and whether the THD applies to voltage or current. The standard THD calculation is performed up to the 49 th harmonic. If so required, the user may increase this to the 99 th. harmonic, or decrease it to a smaller number. Like with other parameters, a first order display filter may be used to smooth fluctuating readings.

Printing Basic and Harmonic Data

The 250xAH family can print all data directly to a PC compatible parallel printers, either via the parallel printer port, or via either of the two serial ports. The parallel printer requires a standard (Centronics) cable, whereas the serial ports require hardware (RTS/CTS) handshaking.

The 250xAH has been operated with most printers, but occasionally compatibility issues arise. These are generally due to some (minor) difference in printer control signals. Generally, connecting the printer, and then turning it off and back on, will solve the problem.

The 250xAH instrument family uses the extended character set, as supported by IBM compatible (Proprinter) type printers. Laser printers should be set to a characters set which includes the characters such as Ω (Omega) , which are frequently used in electrical applications. The character set which gives good results on most printers is PC-8.

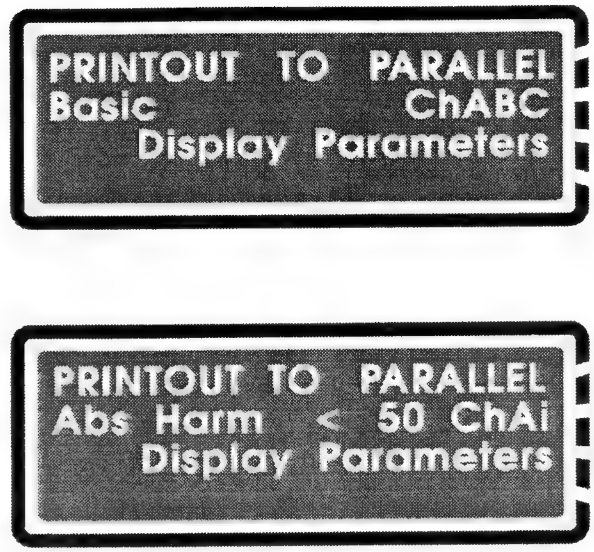


Fig. 19

A data printout can be generated by pressing the "Print" button, and then selecting the appropriate port and report format. Fig. 19 gives a few examples of print menu displays. Note that if the analyzer's serial ports are also set for Printer mode, the parallel port is moved down to the "fifth" display line. So, the user has to push the down arrow key to scroll to be able to select the parallel printer. After the parallel printer is selected, the PRINTOUT TO PARALLEL display will appear.
The available selections are to print "Basic" data, "Basic + Accum", "Absolute" harmonics in Amps, or "Relative" harmonics as a percent of the fundamental current. The user may also printout the currently defined display lines. A number of application specific print formats are being added on a regular basis, and the user can select these as well.

When selecting Harmonic print, the user must select whether to print voltage or current harmonics, and for which channel. The instrument will default to print the first 50 current harmonics for Ch-A as shown in Fig. 19. The next page shows a (50 % reduced) copy of actual data printout. Both, the Basic data, and the Harmonics Data printout examples are shown. Even though many additional parameters may be needed for specific applications, the Basic and Harmonic printout include the vast majority of data one may need.

Fig. 20

IEC555.2 and IEC555.3 Test Setup

The instrument setup for IEC555 testing is very easy. All the user needs to do is to select the desired setup via the Quick menu, and then define display lines as required for the particular test.

If the user attempts to set up a display line for either IEC555.2 or IEC555.3 status, while the analyzer is not configured for this test, the instrument will display an appropriate message. The user may configure the instrument for IEC555.2 compliant harmonics analysis, and measure all other parameters as well. In the case of IEC555.3 testing, the instrument is fully dedicated to performing all the analysis in accordance with the IEC-868 Flicker Meter specifications. These analysis are so demanding that only IEC555.3 parameters may be displayed.

In the case of IEC555.2 current harmonics, the main impact on analysis is, that every data sample block is acquired over exactly 16 cycles of the fundamental frequency (320 ms for 50 Hz systems). Since the instrument synchronizes its sampling to within 0.03 % of the fundamental frequency, a rectangular window is applied to the data samples. Thus a total of 8192 data points for voltage, and for current, are equally weighted for analysis purposes. The power level is calculated using the same 1.5 second time constant which is applied to the calculation of individual harmonics. In Fig. 21, an axample of a Class A, Steady State test is shown. The user may change the test class to either A, B, C, or D. The standard defines two test methods, Steady State and Fluctuating (transitory) harmonics. Again, the display line may be modified to accommodate the required test.

The instrument compares all harmonics against the standard's limits for the selected Class, and decides on a PASS/FAIL status accordingly. note that it may take 2.5 minutes for Fluctuating tests, before a Pass/Fail status is generated.

Individual channels may be configured to acquire data in IEC555.2 compliant fashion, or may be set up in a different fashion. The example given in Fig. 21 shows the configuration selection, which may be accessed via the System button, and the Channel Grouping menu.

As discussed earlier, the Advanced Setup gives the user additional flexibility to fine-tune the configuration. Notice that the Source Checking has to be turned "ON" for full compliance testing. The standard calls for the source to meet stringent requirements while the test is in progress,(see Fig.11). This of course demands a compliant power source as discussed earlier.

For pre-comliance testing, the test may be set up with standard utility power, and the source checking may be turned off.

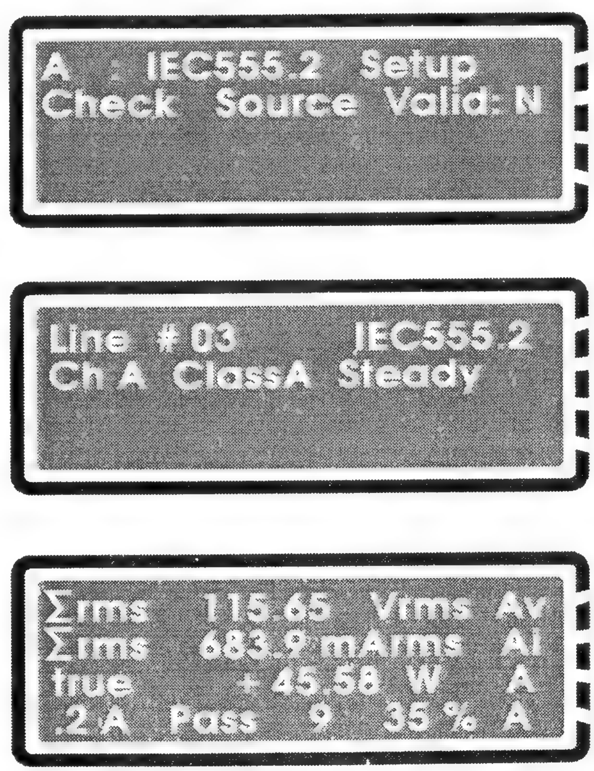


Fig. 21

IEC555.2 Test Setup

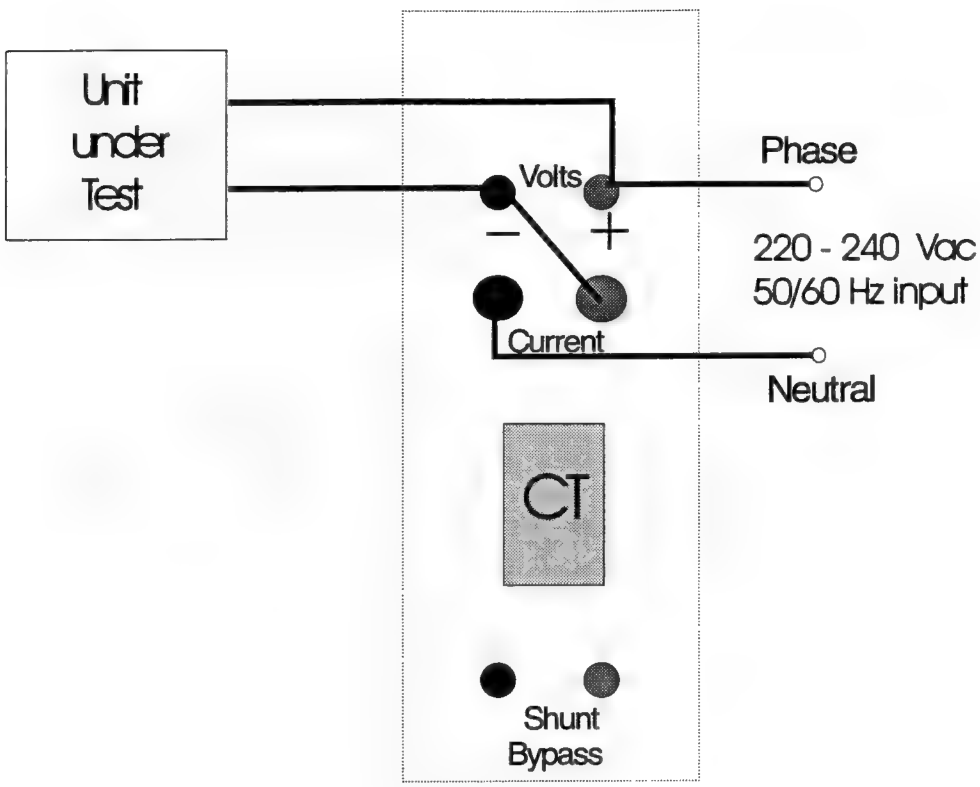


Fig. 22

Once the analyzer (or the selected channel) is configured for IEC555.2 testing, a display line may be defined as shown in Fig. 21. This line will show wether the UUT passes or fails the test, and which harmonic is the highest. In the example, the unit under test passes, with the 9 th harmonic being the highest, at 35 % of the standard's limit. If source checking is turned on, the analyzer may display a "Chk Srce [xx]" message, with "xx" identifying the problem the source voltage is having. If this happens, the source problem needs to be corrected before a full compliance test can be completed.

The connection diagram for a single phase IEC555.2 compliance test is shown in Fig. 22. In this case, the use of the internal shunt is assumed. The user may also select the HALL effect CT, or the Bypass input. For higher currents (> 10 Arms), the use of the CT is recommended, although not mandatory , to comply with the standard's requirement that the instrument shall not cause a voltage drop of > 0.15 V-peak through its measurement circuit. The internal shunt of 5 milli-Ohm iprovides compliant analysis up to currents of 30 Amp peak. The user may define a display line to show peak current to quickly verify existing conditions. The CT poses no burden at all, hence is ideal for higher current levels. For test setups where the user has an external shunt, the voltage accros this shunt is connected to the Bypass input.

In the case of IEC555.3 tests, only voltage is measured. The standard demands the use of a Cenelec standard impedance which simulates the impedance of the public supply system. This standard impedance is connected between the source and the unit under test. The analyzer then measures the voltage at the input terminals of the UUT.

The standard defines a parameters that need to be measured, and then evaluated in accordance with IEC868, and Amendment I to this specification. Each of the parameters specified in IEC555.3 may be defined as a display line.

Also, the user must define a test time, as Flicker tests may vary from 10 mintues to over 2 hours. The instrument will default to 120 minutes, which is the time required to measure the long term Flicker level. This parameter is called "Plt".

Fig. 23 shows how the Flicker test is started, and the associated displays. First, the user selects the IEC555.3 configuration via the Quick key. After pressing the Quick key, press the display line no. 2 key to step through the various Quick configurations. With the second display line showing "IEC555.3 Channel Use", press the Enter key twice.

Next, the SYSTEM CONFIGURATION is accessed through the System key, and the display (for a 3 channel instrument) lookes similar to the one shown in Fig. 23. After pressing the key associated with Ch-A, the display will switch to "Abort". With this shown, press the Enter key to commence the test.

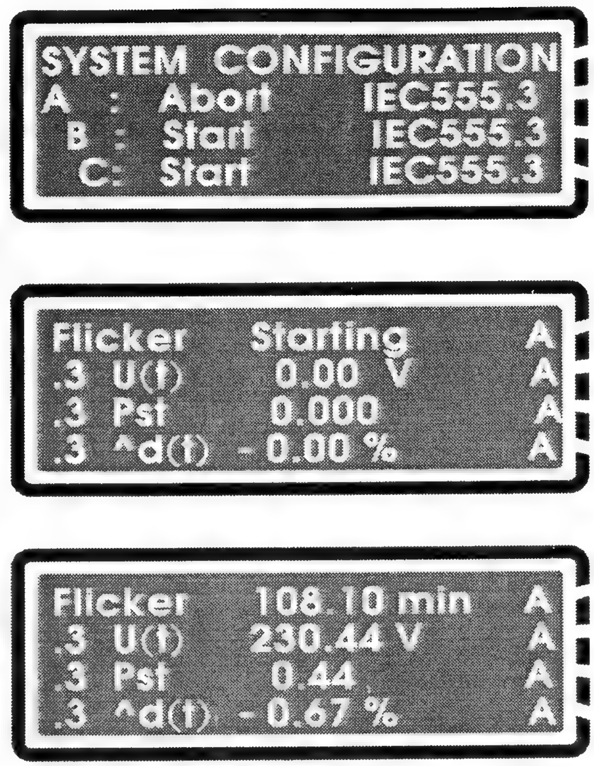


Fig. 23

The display will now show that the Flicker test is starting. It may take several minutes before the test is actually in progress. The reason for this is that the analyzer first has to establish a steady state condition. The IEC555.3 standard demands that the instrument evaluate the rms level of every half cycle (every 10 ms) against the steady state level. Since small voltage fluctuations of only 0.25 % can represent an intolerable Flicker level of , it's important to accurately determine the nominal voltage against which the half cycle values are compared. Also, the instrument must measure changes in steady state voltage (dc). Thus steady state must first be established, before analysis can commence.

Once the Flicker test has started, the display will provide the time left to complete the test, as shown in the bottom display of Fig. 23. The user may define display parameters either before the test starts, or while the test is in progress. All parameters are continuously calculated and updated. Defining a display line merely determines which parameters are "pulled" from memory, and shown on the display. As mentioned before, the user may define up to 50 display lines, and scroll up/down to view the desired lines.In the example, the instantaneous value of the voltage at the UUT's terminals is shown , this is U(t). Also, the short term Flicker (Pst) is displayed, along with the maximum value that has been observed for the parameter d(t).

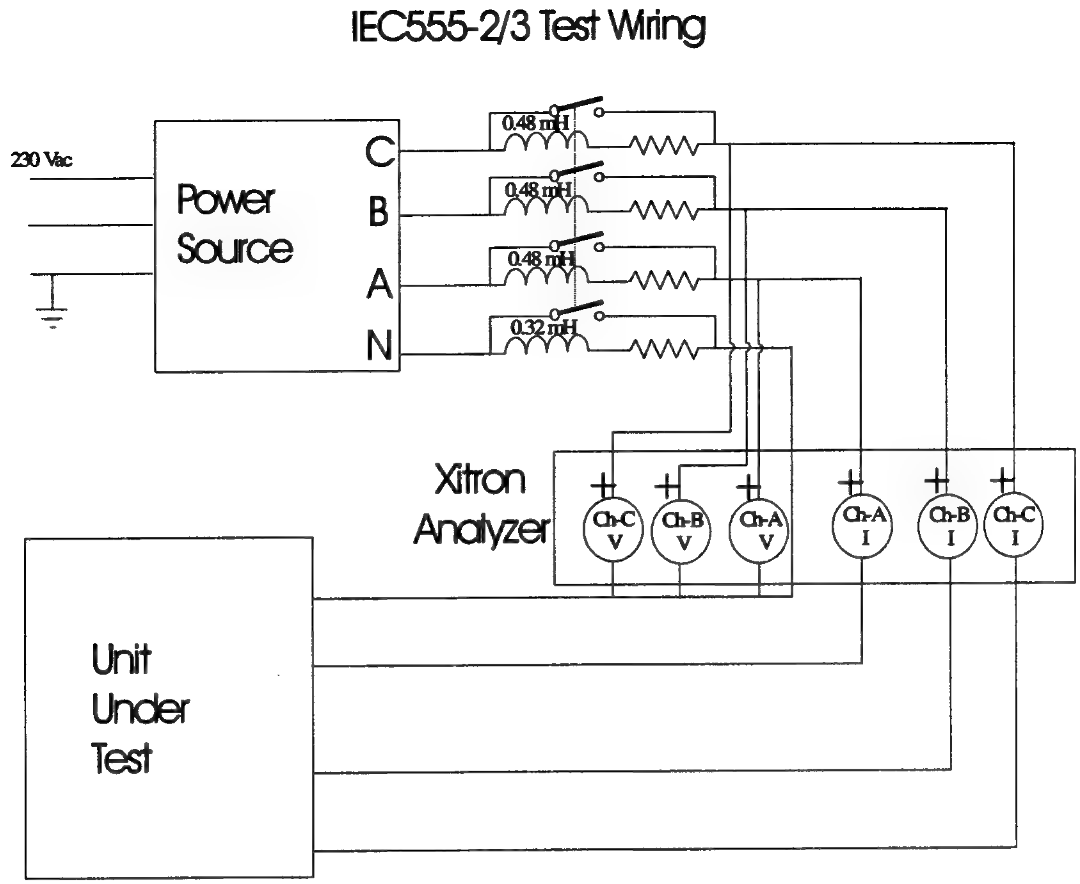


Fig. 24

The analyzer can display all instantaneous IEC555.3 parameters, as well as the maximum values that occured while the test progresses. At the end of the test, the analyzer displays a PASS/FAIL message.

Flicker tests may be done on single or three phase systems. For balanced three phase systems, the test on just one phase is acceptable. In unbalanced systems, three phase simultaneous testing is required. Since the Flicker test is very demanding from a computational/analysis viewpoint, the analyzer will always set all three channels (if fitted) in Flicker configuration, even if only one channel is being used. Unlike the case of IEC555.2 testing, where individual channels can be set to different configuartions, it is not permitted to configure channels for other tests, while Flicker tests are being performed. Channels may have different test times in IEC555.3 mode, however.

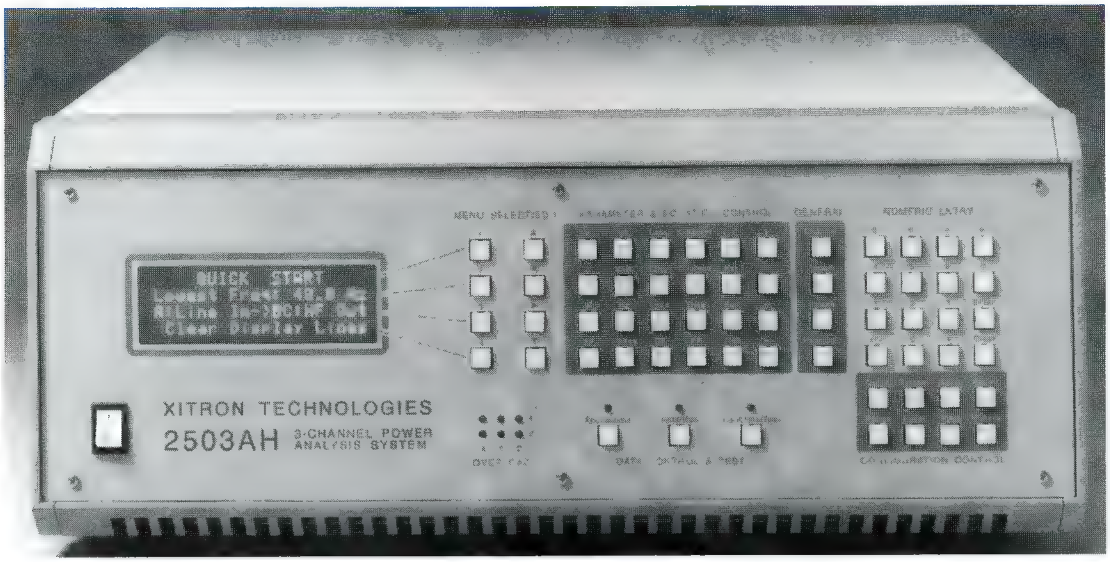
Fig. 24 shows the connection diagram for a 3-Phase IEC555 test setup. Notice that the setup will satisfy both, IEC555.2 and IEC555.3 testing. For IEC555.2 harmonics testing, the standard impedance can be short circuited by relays. This configuration is only one of several ways the test can be setup. The user may either build the standard impedance network, or purchase the model 2520-1P (single phase), or 2502-3P three phase version, from Xitron.

Analog Input/Output Option

The 2503AH analyzer family is available with several options. The DRO, AIO, and AIOM options provide analog input/output capabilities, which can be used in monitoring applications, motor/control system analysis, multi-instrument synchronization etc.

High Performance Power Analysis Systems

2501/2/3AH



- 18 bit, 500 KHz sampling speed provides 0.05 % basic accuracy
- Ultrafast FFT's per channel produce measurements in 10 ms
- 1200 V RMS, 40 Amp RMS, internal shunt and HALL effect CT's
- Pre-configured for ballast, motor, power supply & appliance tests
- IEC-555 compliant Harmonic and optional Flicker Analysis built in

The 2501/2/3AH family of instruments provide the most advanced power analysis capability for lighting, power conversion, and appliance test and development applications. The analyzers measure power, voltage, current and frequency up to 500 KHz with the utmost precision.

Available parameters include V-A-W, Power Factor, Crest Factor, K Factor, THD, Harmonics, Phase, VA, VAR, W.Hr, Triplens, Impedance, Inrush-Mean-Peak values, Efficiency-Loss etc.

Xitron power analysis instruments have set a defacto standard for production testing in the lighting industry. Independent channel control and unparalleled flexibility and speed, have made the 2503AH the instrument of choice in 3 phase power analysis.

The 2501/2AH offer cost effective solutions for single phase applications such as power supply and appliance testing. The stand alone IEC-555 testing capability is a unique Xitron feature.

XITRON
TECHNOLOGIES

Xitron Technologies Incorporated
6295 Ferris Square, Building D
San Diego, California 92121

Tel: (619) 458-9852
Fax: (619) 458-9213

Application specific configurations

The 2501/2/3AH power analysis instruments come with preprogrammed configurations for electronic ballast testing, several 3 phase setups, and motor test configurations. You may configure the 2503AH as 3 independent power analyzers, or as the most advanced 3 phase analyzer. For electronic ballast testing, one channel may be set up to measure line frequency data, while the other two channels measure the high frequency signals. This therefore yields a direct efficiency measurement. For maximum flexibility, the user may store up to 65,000 application specific configurations in the instrument's non-volatile memory. A high accuracy version with a total inaccuracy < 0.05 % is available for the most demanding tasks, such as wattmeter testing.

Harmonic & Spectrum Analysis

The most powerful feature of the 2501/2/3AH family, is the speed and precision of its signal analysis capability. Each channel has its own synchronization and two powerful digital signal processing (DSP) chips. One chip performs all the synchronization and sampling computations, while the other does the Fast Fourier Transform of current and voltage signals sampled with true 18 bit resolution. Both current and voltage have independent but fully synchronized A/D waveform capture sections. In fact, the user may transfer the captured waveform data to a computer for display or special processing purposes.

The dual DSP architecture per channel results in ultra fast harmonic analysis. Harmonic analysis can be produced in as little as 10 milliseconds, or measurements may be integrated over more than a day. The user may set any measurement interval, perform synchronous averaging on harmonics, and even perform full spectrum analysis to detect non-harmonic signal content. The system's main processor controls all display, data storage and I/O functions, thus allowing each channel to perform its analysis at maximum speed.

IEC555 compliance testing

The high resolution and fast processing give Xitron power analyzers the unique capability to perform complete IEC555 testing in a stand alone fashion. The user can select a simple Pass/Fail type display, or report all harmonics per IEC555.2 for each of the individual classes. The 2501/2/3AH family meets every detail of the IEC555 requirements, including the max. 0.15 V peak voltage drop across the instrument and the no gap/overlap 16 cycle stipulation for fluctuating harmonic measurements.

IEC555.3 Flicker analysis is even more powerful. The user may display Ut, Pst, Plt, dt, dmax etc. while the test progresses. The system architecture allows the Xitron power analyzers to perform half cycle by half cycle measurements as well as the Laplace transform, and update the instrument display and any connected computer, without losing even a single data point.

Data display & interface flexibility

The 2501/2/3AH instruments permit the user to define as many display and printout lines as needed. The user may define individual lines in a logical fashion, scroll them up or down on the display, or print them with a standard PC compatible printer. There is also a choice of several predefined printouts, including harmonics, basic parameters, as well as user defined reports.

Computer control is easy through the IEEE-488 interface, or via the second RS-232 port. Since all channels perform their own processing and the I/O is handled by the main processor, the power analyzers offer unparalleled interface speed. The analog/digital I/O option provides the most advanced motor testing capability on the market. The 2503AH can measure torque, speed and power, and compute motor efficiency on the fly. 8 Analog and 16 digital outputs can be set to track and alarm on specific parameter ranges, while 8 digital inputs are monitored also.

XITRON 2501/2/3AH specifications

Input ranges

User may select fixed or autorange.
Voltage: 15-30-60-150-300-600-1200 V RMS.
Current:
Shunt; 0.05-0.1-0.2-0.5-1-2-5-10-20 A RMS.
Int. CT; 5-10-20-40 A RMS.
Bypass;12.5-25-50-125-250-500 mV RMS.
1.25-2.5-5 V RMS.

Resolution

Better than 0.05 % of range.

Voltage & current accuracy

DC Volts: 0.05 % $\pm$ 0.15 % range $\pm$ 50 mV.
DC Amp: 0.05 % $\pm$ 0.15 % range $\pm$ 2 mA .
AC Volts/Amp:

0.001 Hz - 10 KHz:	0.05 %
10KHz - 20 KHz:	0.10 %
20KHz - 50 KHz:	0.33 %
50KHz - 100 KHz:	0.55 %
100KHz - 200 KHz:	1.00 %
200KHz - 500 KHz:	2.35 %

For voltage add 0.05 % of range + 20 mV.
For internal shunt add 0.05 % of range + 2 mA.
For shunt bypass add 0.05 % of range + 0.01 mV.
Min input > 10 % of range (1 % with filter on).
High Accuracy option: 0.05 % of reading for freq. 40 - 400 Hz, and input > 25 % of range.

HALL effect CT Accuracy

DC Amp: 0.15% $\pm$ 0.15% of range $\pm$ 25 mA.
AC Amp:

0.1 Hz - 10 KHz:	0.25 %
10KHz - 20 KHz:	0.65 %
20KHz - 50 KHz:	2.25 %
50KHz -100KHz:	4.25 %

For AC add 0.05% of range + 10 mA.

Crest Factor

Better than 2.5 at full scale input, linearly increasing to 250 : 1 at 1 % of full scale.
For max. inputs of 100 Apk, 3000 Vpk.

Voltage protection

Up to 3000 Vpk continuously. Max slew rate 2500 V/μSec.

Current protection

Max. 500 Amp peak via HALL effect CT.
Max. 100 V peak using shunt bypass input.
Max. 50 Amp peak using internal shunt.

Isolation

Inputs are isolated from each other and ground, for voltages up to 3000 Vpk.

External CT and PT capability

Ratio: 0.000001 - 1000000 to 1, for A/V, A/A or V/V.

Frequency Measurement

0.001 Hz to 500 KHz, 0.01 % of reading.

Measurement Period

User defined from 10 mSec to 27.8 hours.

Settling time

0.0015 mSec (low pass filter disabled).

Low pass filters

User definable 5 Hz - 160 KHz, or disabled.

Filter amplitude accuracy

Add 0.01% /KHz for signal frequencies > 5 KHz.
Filter rejection > 40 dB @ 3 x selected filter frequency.
Current and voltage accuracy specifications apply for input signals < 0.05 x selected filter frequency.

Harmonic & Spectrum Analysis

Bandwidth: 0.001 Hz to 170 KHz .
Max. harmonic: 2047 .
Max FFT size: 4096 point complex FFT.
Typical THD, harmonic and phase accuracy at line frequencies of 50/60 Hz :
THD accuracy: $\pm$ 0.3 % .
Harm. accuracy: 0.03 % of range.
Phase accuracy: 0.1° for freq. < 5 KHz, linearly increasing to 5° @ 170 KHz .
Fully compliant IEC555.2 harmonic analysis .

Exact specification formulae available on request.

Power Factor accuracy

Approximately 0.001 for freq.< 10 Khz (5 KHz w/filt.).
increasing linearly to 0.01 @ 200 KHz (20 KHz w/filt.).

Watt, VA & VAR accuracy

Highest of V*Amp. error, or Amp * V error yields max. error for either Watts, VA, and VAR.

Accumulation accuracy

WHr, VAHr, AHr up to 9999.9 GWHr/GVAHr .
Timing accuracy: 0.01 % + 10 mSec. start/stop error.

Analog I/O option

Up to twelve analog outputs, proportional to user defined offset & span of parameters. Two synchronously sampled analog inputs, for speed/torque/efficiency measurements on electrical motors/drive systems .
Analog inputs may be used for measurement synchronization and frequency measurements .
Analog output level /resolution: 5 V/ 5 mA @ 16 bits .
Analog input level/resolution: 5 V/ 100 mA @ 16 bits .
Input/Output accuracy: 0.1 % $\pm$ 2 mV.
Max. freq. for AC analog inputs: 1 KHz.
Digital Range Output: Contact Xitron Technologies .

IEC555.3 Flicker analysis option

Fully compliant no gap/overlaps half cycle analysis .

XITRON 2501/2/3AH specifications

High Performance Power Analysis Systems

2501/2/3AH

Physical specifications

Power input:	105-130 V or 210 - 260 VRMS autoselect, 50/60 Hz, @ 150 VA max.
Size:	17" wide by 7" high by 14" deep.
Weight:	24 lbs. , 35 lbs. shipping weight.
Operating range:	0°C to 50°C, < 85% RH @ 40°C non-condensing.
Storage range:	-30°C to 65°C,< 95% RH @ 40°C non-condensing.
Configuration:	Benchtop or optional 19" rack mount.

Rear panel control

A contact closure input is provided which may be used to control the run/hold/accumulate function. This contact can be configured as active when closed or open.

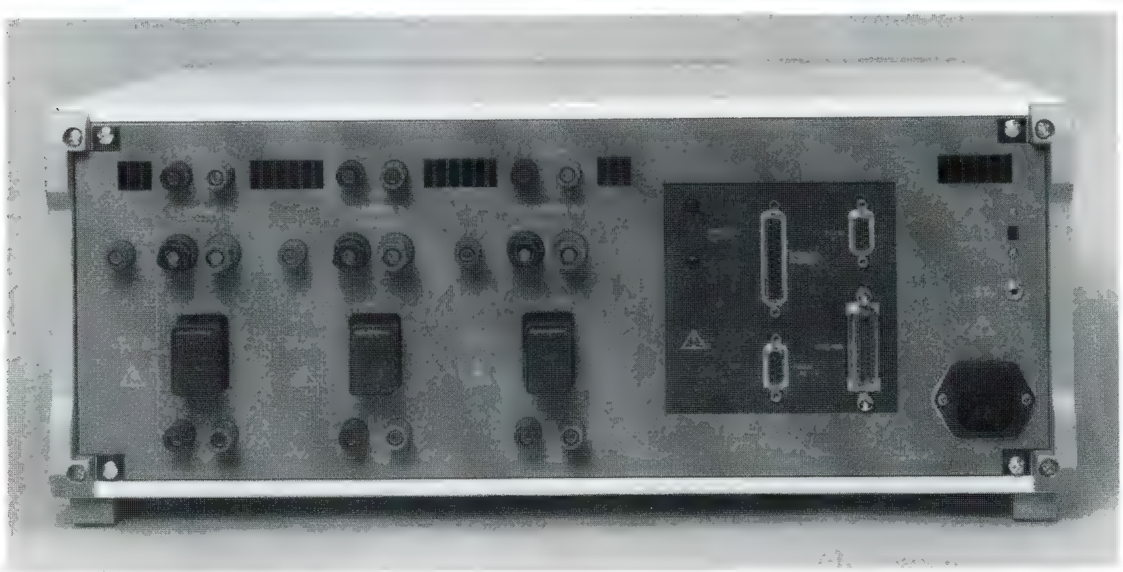
Digital interfaces

IEEE488 (1) :	Full talk/listen capabilities. Contact Xitron for full command set.
RS-232 (2):	Each of the ports may be used for control or for printer output. Baudrates can be set from 1,200 - 38,400 baud. Flow control via RTS/CTS handshake.
Parallel:	Standard Centronics (IBM-PC compatible) interface.

Ordering Information

2501AH single channel analyzer.
2502AH two channel analyzer.
2503AH three phase analyzer.
2501AHF single channel analyzer with Flicker option.
2502AHF two channel analyzer with Flicker option.
2503AHF three channel analyzer with Flicker option.
note: Flicker option includes COPR option.

INT	Digital interface option including IEE-488, 2 ea. RS-232 and parallel printer interface.
HA	High accuracy option.
AIO	12 ea Analog I/O interface option.
AIOM	As AIO but with two synchronously sampled analog inputs.
RE	19" Rack adapter kit.
COPR	Coprocessor option for user defined equation entry (recommended with HIST1/2/4 option).
HIST1	High speed data logging option, 1 MByte memory.
HIST2	High speed data logging option, 2MByte memory.
HIST4	High speed data logging option, 4MByte memory.



Specifications subject to change without notice

XITRON TECHNOLOGIES

Xitron Technologies Incorporated
6295 Ferris Square, Building D
San Diego, California 92121

Tel: (619) 458-9852
Fax: (619) 458-9213

Xitron Technologies Inc

The 2503AH family of instruments offers sophisticated and extremely accurate power analysis capabilities. The product family consists of the 2501AH single, 2502AH dual, and 2503AH three channel analyzers.

The 2503AH family offers unparalleled flexibility and speed. The following are the salient characteristics which allow you to evaluate the instrument's suitability for a given application;

- True 18 bit A/D resolution
- 500 KHz data sampling rate
- 0.05 % V & I accuracy
- Two 32MHz Digital Signal Processors for each channel
- Harmonic & spectrum analysis of voltage and current
- Full stand-alone compliance with IEC555.2 & IEC 555.3

Xitron Technologies Inc
6295 Ferris Square, Bldg D
San Diego CA 92121
Tel: 619-458-9852 FAX 619-458-9213

PERFORMANCE SPECIFICATIONS

General

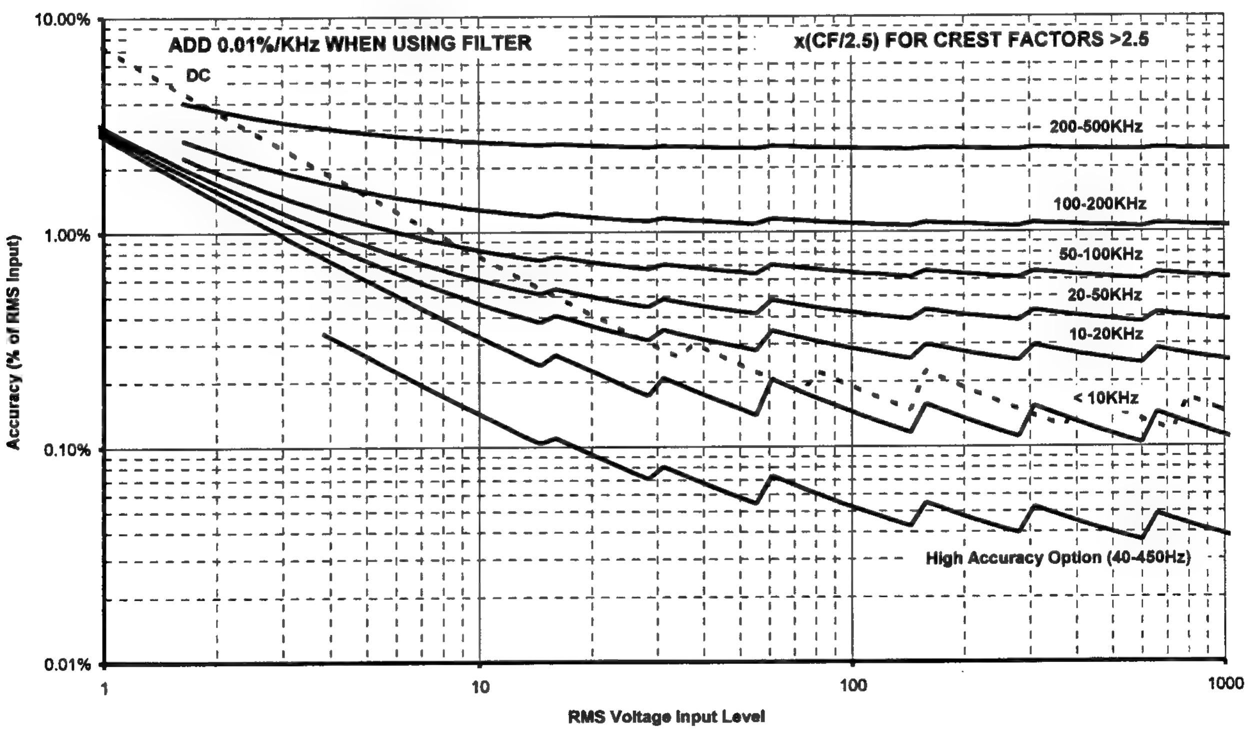
Unless otherwise indicated, all accuracy specifications given in this chapter are valid throughout the specified operating temperature range, for a period of 1 year, following a 30 minute warm-up period. At 1 day intervals, or following temperature changes exceeding 5°C, an Input Calibration sequence should be performed.

Charts show accuracies for either AC only or DC only parameters, for AC+DC or Average Rectified parameters use the higher of the two relevent specifications.

High Accuracy option specifications are for input frequencies between 40 and 450Hz, autoranging enabled, crest factor less than 1.8, power factor > 0.9, 20KHz filter frequency. Signals other than meeting these requirements are specified as the standard accuracies.

Voltage, Current Shunt and Current (Shunt Bypass) input accuracies are typically within 3dB to 5MHz.

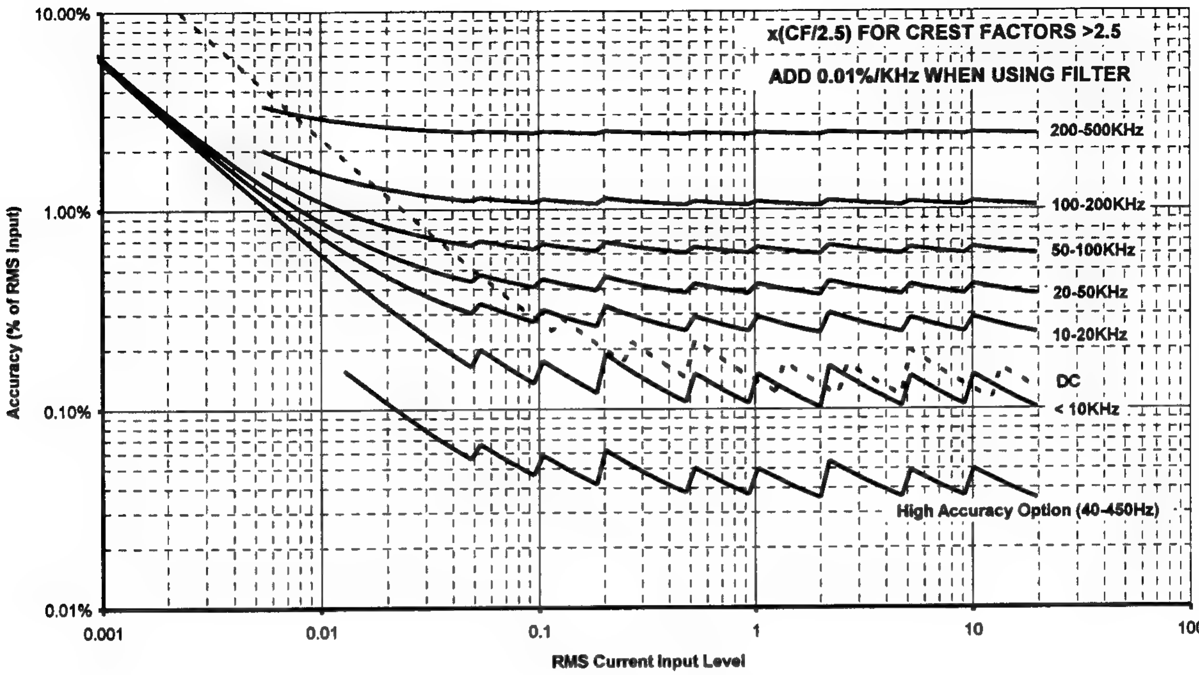
Voltage Input



Ranges :	1200V, 600V, 300V, 150V, 60V, 30V and 15V RMS, autoranging or fixed.
Max. Measurable Peak :	>2.5 times RMS range.
Protection :	Protected up to 3000V peak (2000V RMS) on any range.
Input Impedance :	600KΩ | |5pF from each voltage terminal to current shunt low terminal.
Isolation :	1000MΩ | |10pF from either terminal to chassis ground, 3000V peak max.

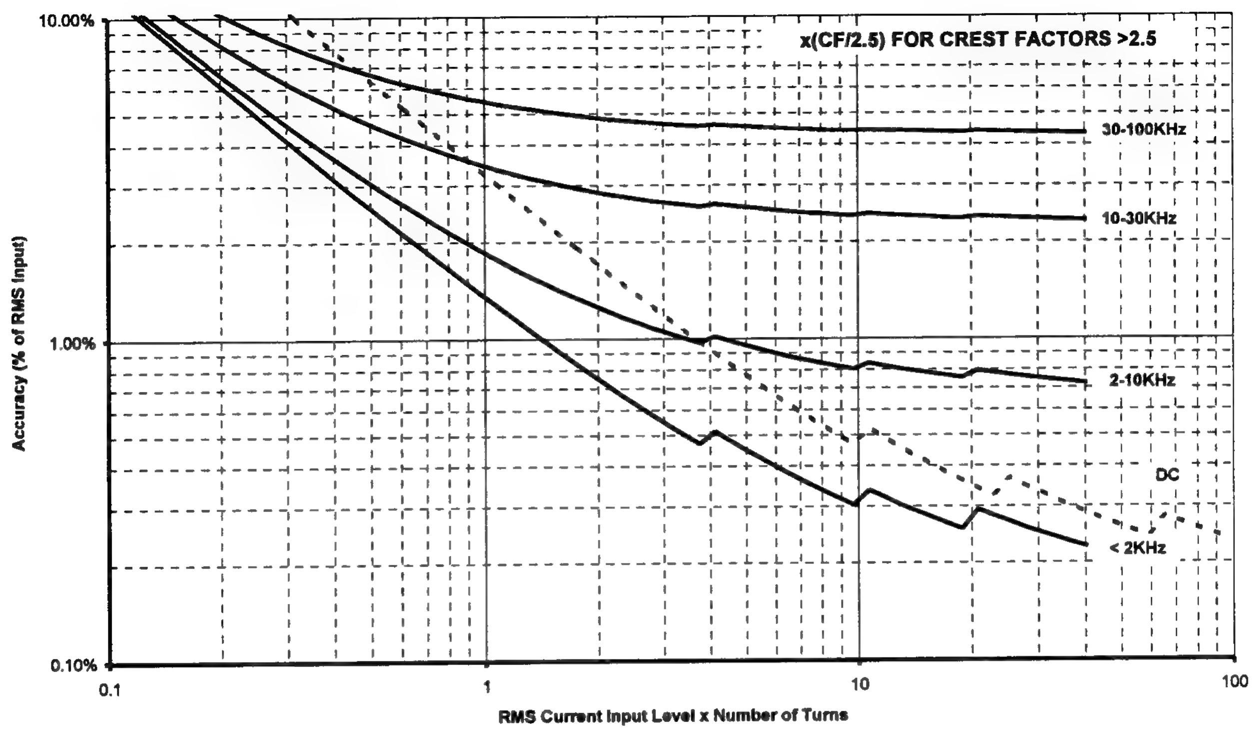
Scaling : User scale factors from 1000000:1 to 0.0000001:1 may be used.

Current Shunt Input



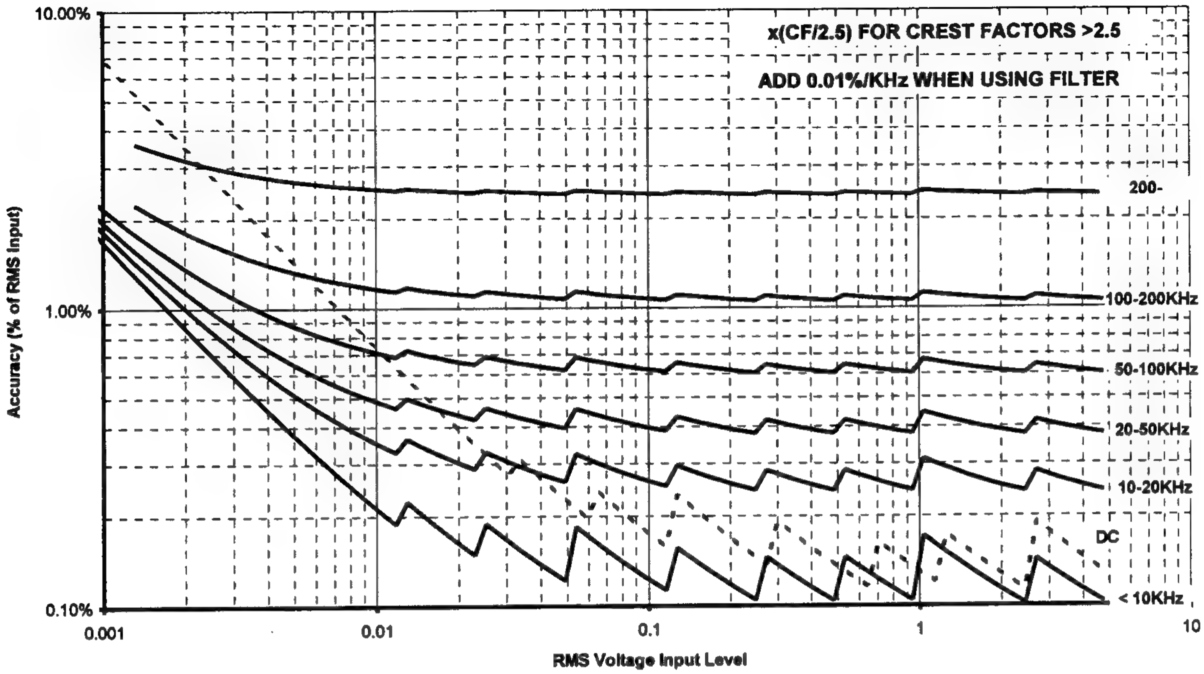
Ranges :	20A, 10A, 5A, 2A, 1A, 500mA, 200mA, 100mA or 50mA RMS, autoranging or fixed.
Max. Measurable Peak :	>2.5 times RMS range.
Protection :	Protected up to 50A peak (25A RMS) on any range.
Burden :	<0.15Ω (below 2A range), <0.02Ω (2A range and above).
Isolation :	1000MΩ | |200pF to chassis ground, 3000V peak max., <2500V/μs.
Scaling :	User scale factors from 1000000:1 to 0.0000001:1 may be used.

Internal Hall Effect Current Transducer Input



Ranges :	40A, 20A, 10A or 4A RMS, autoranging or fixed.
Max. Measurable Peak :	>2.5 times RMS range.
Protection :	None required.
Burden :	Negligable.
Scaling :	User scale factors from 1000000:1 to 0.0000001:1 may be used.

Current (Shunt Bypass) Input



Ranges :	5V, 2.5V, 1.25V, 500mV, 250mV, 125mV, 50mV, 25mV or 12.5mV RMS, autoranging or fixed.
Max. Measurable Peak :	>2.5 times RMS range.
Protection :	Protected up to 100V peak (50V RMS) on any range.
Input Impedance :	1KΩ (below 500mV range), 10KΩ (500mV range and above).
Isolation :	1000MΩ | |200pF to chassis ground, 3000V peak max., <2500V/μs.
Scaling :	User scale factors from 1000000:1 to 0.0000001:1 Amps/Volt may be used.

Input Filtering

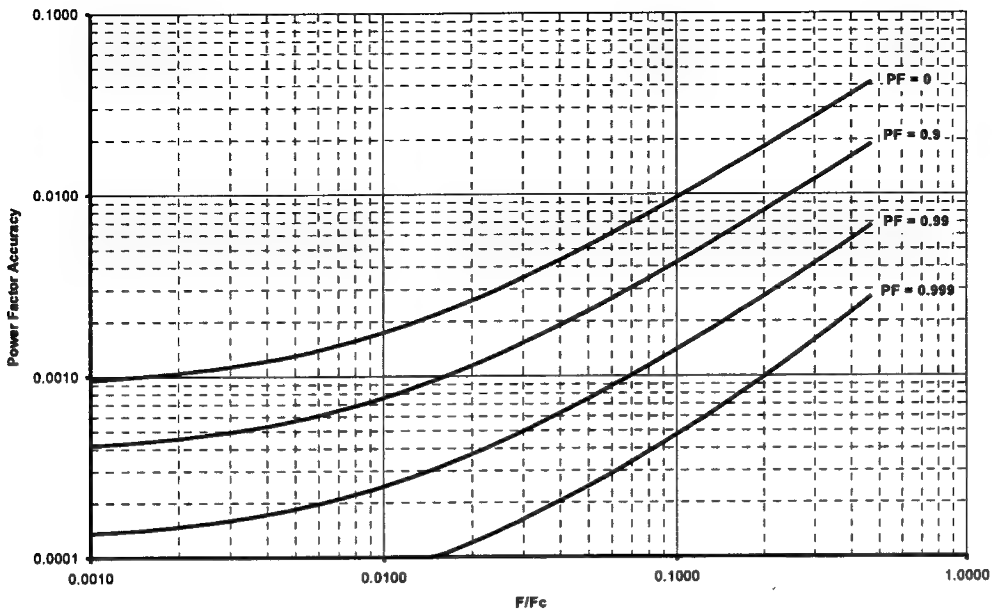
Low Pass Filters :	None or any 3dB corner frequency (Fc) between 10Hz and 160KHz.
Attenuation :	>40dB at twice Fc.

VA Accuracy

VA accuracy is the addition of the relevent percentage accuracies for the voltage and current inputs from the preceding charts.

For the high accuracy option, the percentage VA accuracy is the higher of the relevent percentage accuracies for the voltage and current inputs from the preceding charts.

Power Factor Accuracy



In this graph, Fc is the filter corner frequency or 500KHz (100KHz if using the internal Hall Effect transducer), whichever is the lower frequency. F is the fundamental power frequency. Extrapolate between curves for accuracy at other power factors.

Watts Accuracy

%Watts accuracy = %VA accuracy + (PF accuracy times 100/PF).

At low power factors (less than 0.5) this is better expressed in terms of absolute Watts accuracy as follows -

Watts accuracy = (%VA accuracy times Watts / 100) + (PF accuracy times VA)

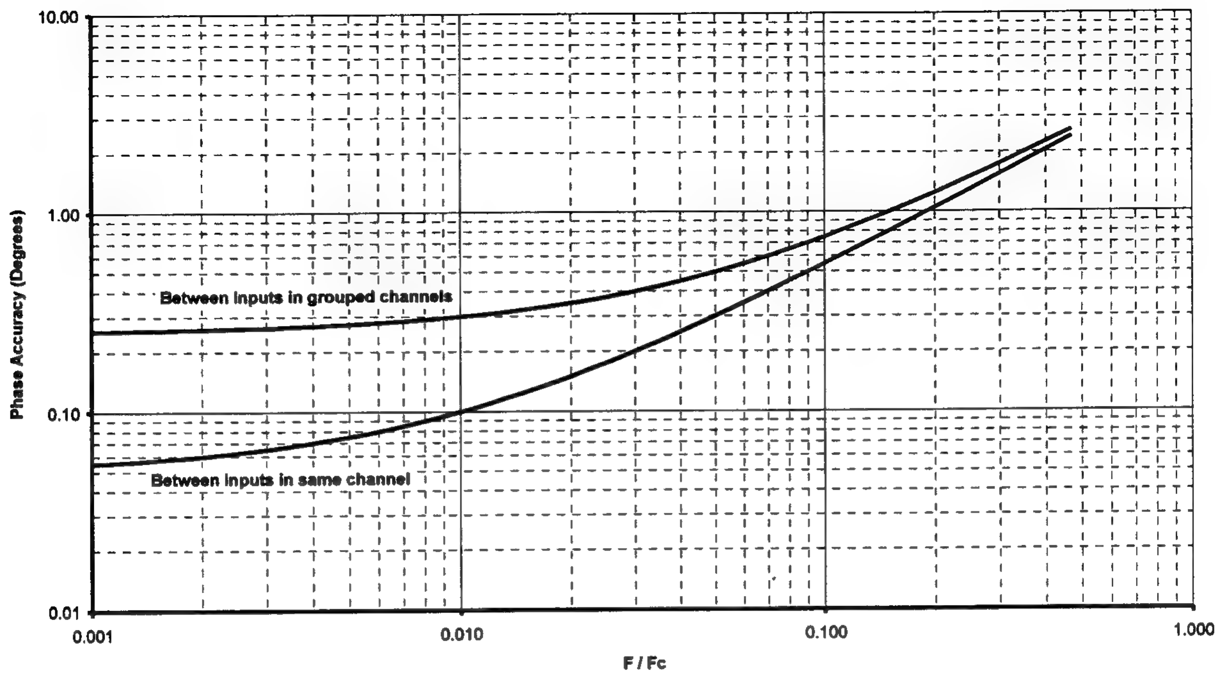
VAR Accuracy

%VAR accuracy = %VA accuracy + ((1-PF) accuracy times 100/(1-PF)).

At high power factors (greater than 0.5) this is better expressed in terms of absolute VAR accuracy as follows -

VAR accuracy = (%VA accuracy times VAR / 100) + ((1-PF) accuracy times VA)

Phase Accuracy



In this graph, Fc is the filter corner frequency or 500KHz (100KHz if using the internal Hall Effect transducer), whichever is the lower frequency. F is the measurement frequency.

Frequency Measurement

Accuracy :	0.01% + (0.05% divided by measurement period in seconds).
Min. Fundamental Signal :	5% of range.
Frequency Range :	0.0005Hz to 500KHz.
Technique :	Period measurement of filtered signal using a "tracking" bandpass filter having a bandwidth of 0.8 to 1.2 times the measured fundamental frequency.
Harmonic Rejection :	Detects fundamental component having an amplitude down to 30% of total signal.
Abnormal Cycle Rejection :	Rejects cycles having >20% deviation from the mean cycle period, a maximum of 10% of the cycles in the measurement period may be rejected.
Measurement Filtering :	Optional "moving average" filtering may be applied.
Response Time :	<1.5 measurement periods.

Harmonic Analysis

IEC555.2 Analysis :	Uses 16 fundamental cycle window period, using rectangular window with no overlap and no gaps between window periods. Uses 4096 point Fast Fourier Transform with sampling frequency maintained within 0.01% of 256 times the fundamental frequency.
Standard Analysis :	User definable window period between 1 and 512 fundamental cycle periods, using rectangular window with no overlap and with no gaps for fundamental frequencies less than 100Hz. Uses automatically selected size (256 to 4096) Fast Fourier

	Transform with sampling frequency maintained within 0.01% of relevent ratio from the fundamental frequency.
Windowed Analysis :	User definable window period between 8 and 512 fundamental cycle periods, using a modified Blackman-Harris window with no overlap and with no gaps for fundamental frequencies less than 100Hz. Uses automatically selected size (256 to 4096) Fast Fourier Transform with sampling frequency maintained within 0.01% of relevent ratio from the fundamental frequency.
Frequency Range :	0.0005Hz to 150KHz, up to 2047th harmonic.
Abs. Single Harmonic :	0.02% of total signal + (0.01% of total signal times frequency of harmonic in KHz) + (relevent percentage accuracy specification times the harmonic amplitude level) + (0.01% of input range).
Abs. Harmonic Range :	Square root of sum of squared accuracy at each harmonic. For low frequencies (<500Hz) and low harmonic content (<20% of signal) this approximates to (0.02% of total signal + 0.01% of input range) times the square root of the number of harmonics.
THD Accuracy :	Square root of number of harmonics times [0.02% + (0.02% of total signal times frequency of fundamental in KHz) + (0.02% times input range/fundamental amplitude)].

Accumulated (Integrated) Parameters

Control :	Via front panel, IEEE488 or RS232 interface, or rear panel TTL/relay contact input. Rear panel input may be active high or active low, and is debounced for circa 0.05s.
Accumulation Period :	0.1s to 100 years.
Timing Accuracy :	Front Panel Control : 0.02% + 0.1s Rear Panel Control : 0.02% + 0.05s Interface Control : 0.02% + 0.02s

Peak Parameters

Min. Impulse Width :	Repetitive : 100ns (unfiltered), 500ns (filtered), minimum of 100 impulses per measurement period. Single : 4µs
Accuracy :	As relevent input accuracy specifications at the frequency of the impulse (use 1/impulse period if unknown). Valid for impulse frequencies less than the filter corner frequency.

Date and Time

Accuracy :	0.005%

Analog Outputs (Options AN12 and AIO12 only)

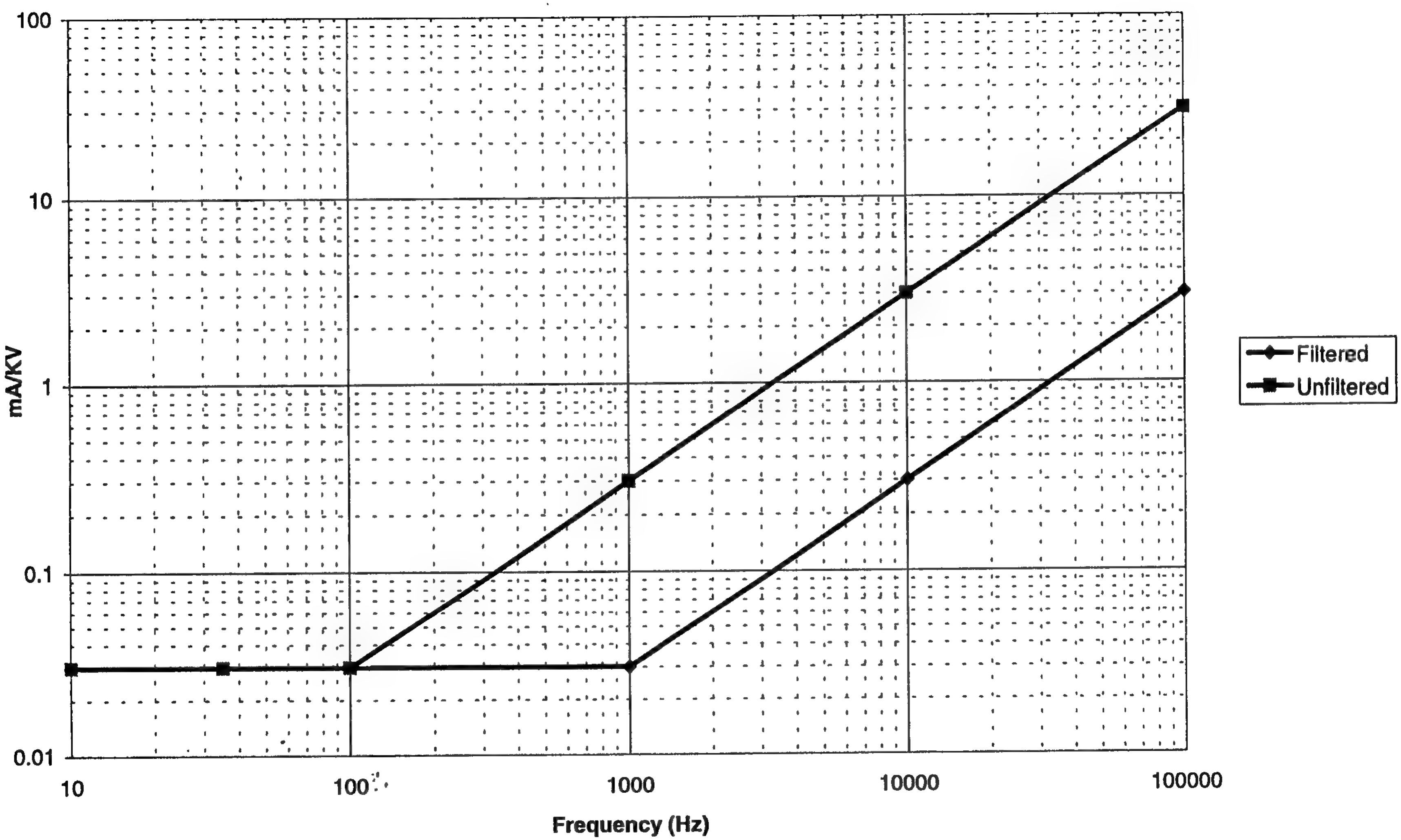
Ranges :	User defined minimum and maximum outputs (for each output) in the range -5V to +5V or -5mA to +5mA.
Usage :	User defined parameter, difference between parameters or ratio of parameters, for each output.
Span :	User defined minimum and maximum parameter values corresponding to user minimum and maximum output levels for each output.
Settling Time :	<10ms. following change in parameter.
Accuracy :	Voltage : 0.02% of output level + 200µV. Current : 0.05% of output level + 500nA.

Output Impedance :	Voltage : <0.5Ω (5mA max.) Current : >100KΩ (5V max.)

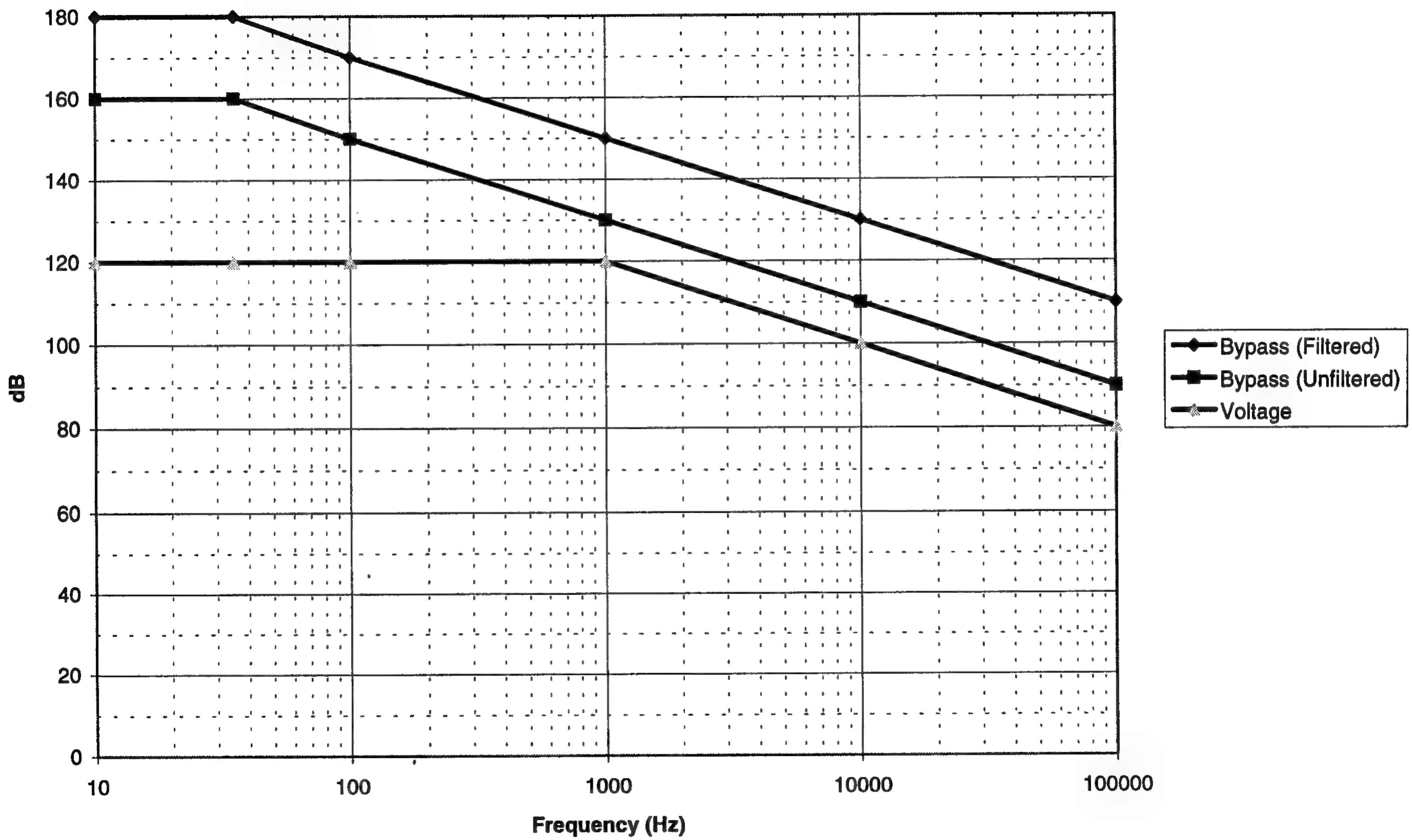
Analog Inputs (Option AIO12 only)

Ranges :	-5V to +5V or -5mA to +5mA.
Amplitude Accuracy :	Voltage : 0.02% of input level + 200µV. Current : 0.05% of input level + 500nA.
Frequency Accuracy :	0.01% + (0.01% divided by measurement period in seconds) in frequency range 0.0005Hz to 50KHz
Isolation :	1MΩ ||25pF from either terminal to chassis ground, 100V peak max.
Protection :	Up to 100V or 100mA peak
Measurement Period :	Synchronized to either Channel A, B or C to within 1ms.
Input Impedance :	Voltage : 1MΩ ||25pF. Current : 100Ω.

COMMON MODE REJECTION SPECIFICATION FOR 250XA FAMILY
(Shunt Input)



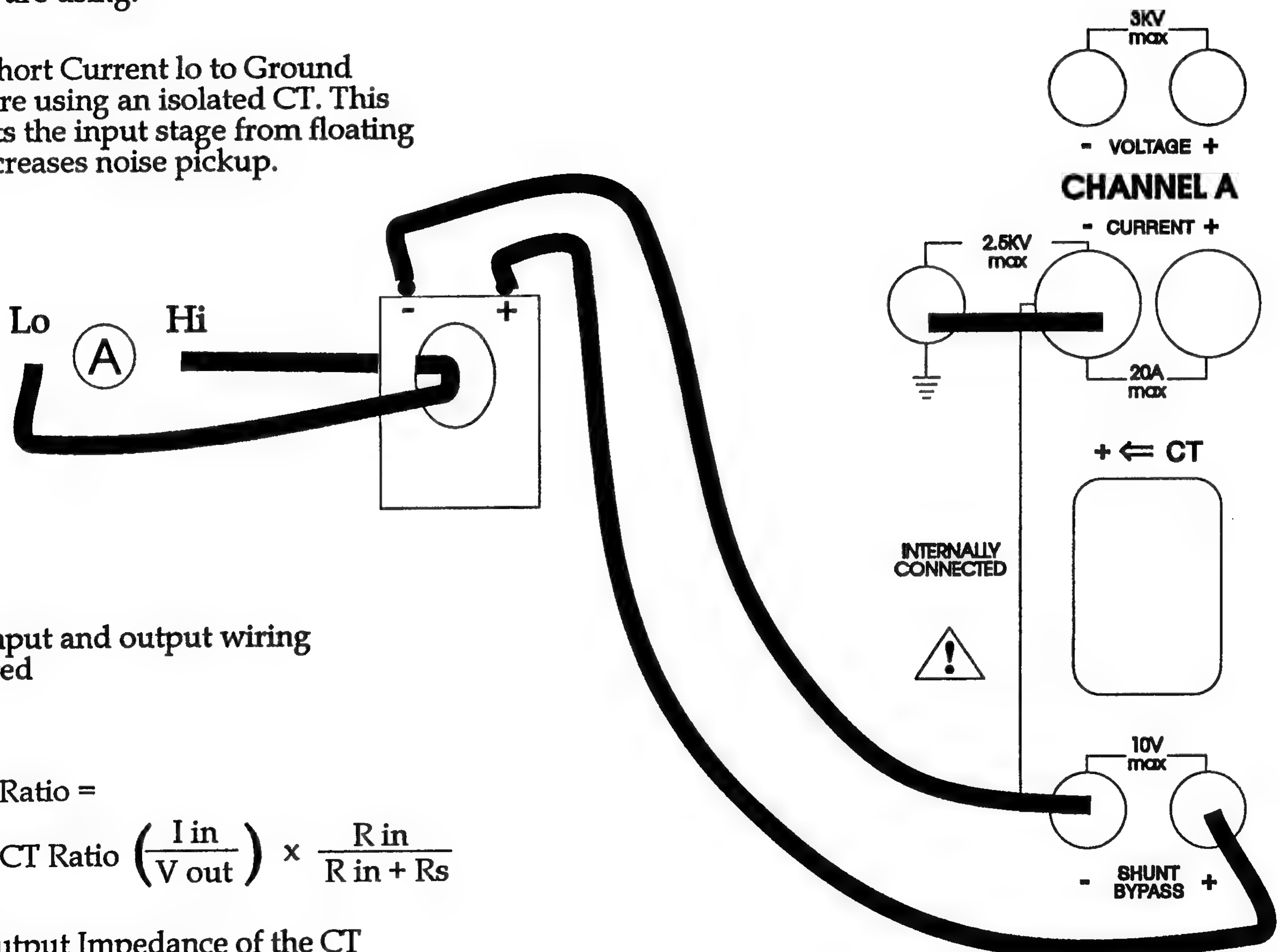
COMMON MODE REJECTION SPECIFICATION FOR 250XA FAMILY
(Voltage and Bypass Inputs)



External CT Connection
Current/Voltage Transformer

Set the CT Ratio to match the CT you are using.

Note: Short Current lo to Ground if you are using an isolated CT. This prevents the input stage from floating and decreases noise pickup.



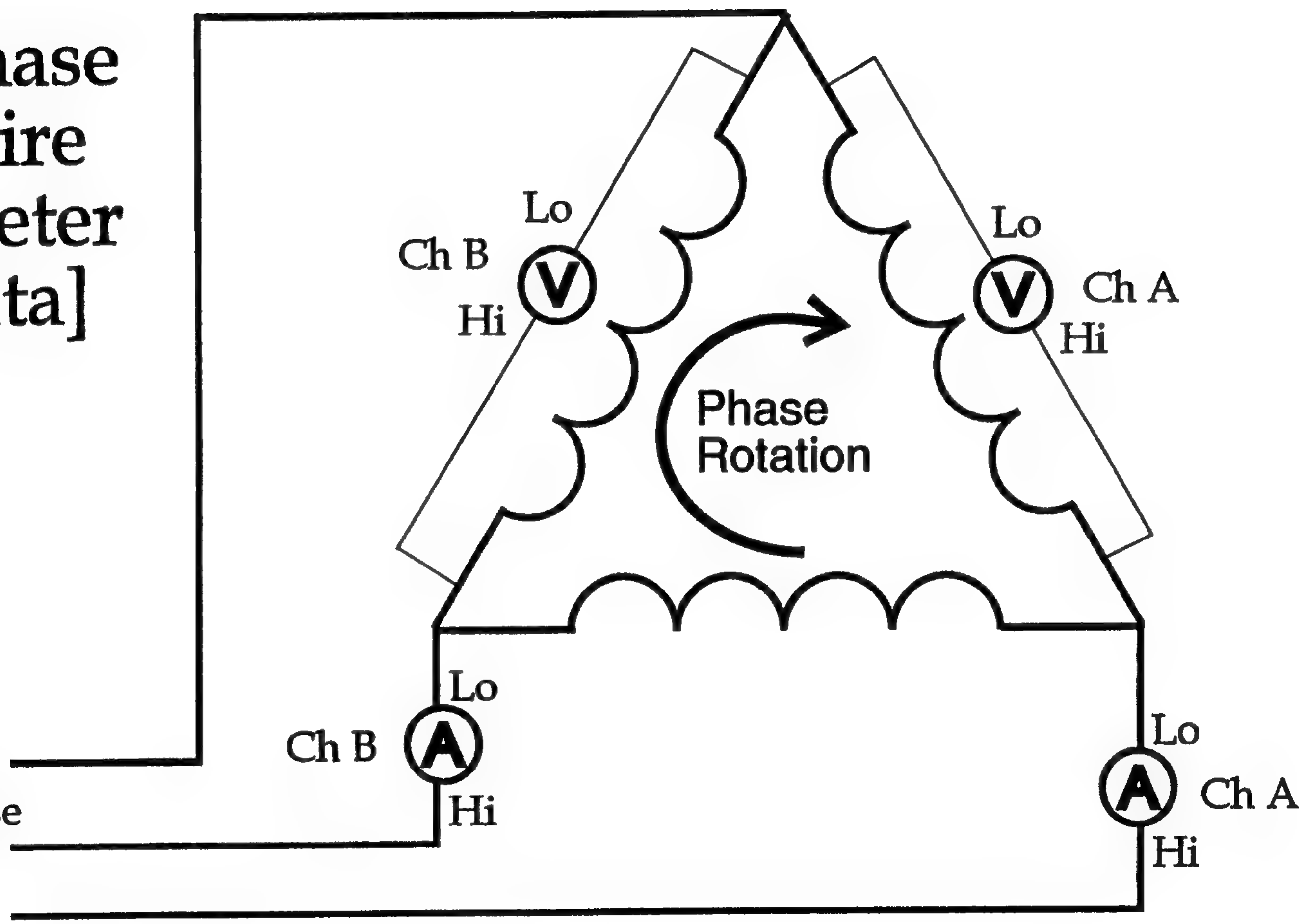
Keep input and output wiring separated

Set CT Ratio =

$$\text{Actual CT Ratio} \left(\frac{\text{I in}}{\text{V out}}\right) \times \frac{\text{R in}}{\text{R in} + \text{Rs}}$$

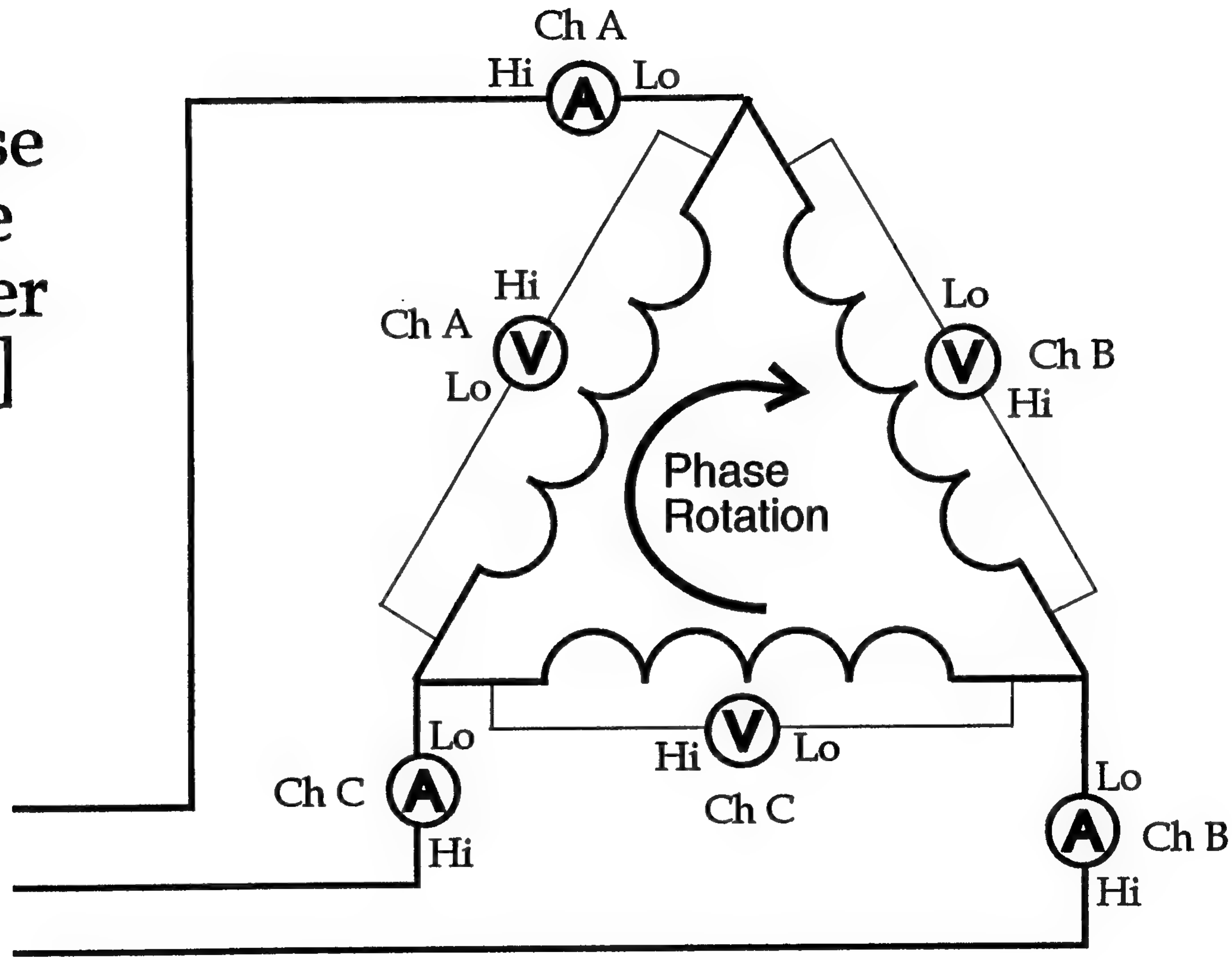
Where:
Rs = Output Impedance of the CT
R in = 1Kohm (250mV & below)
or 10Kohm (500mV & above)

3-Phase
3-Wire
2-Meter
[Delta]



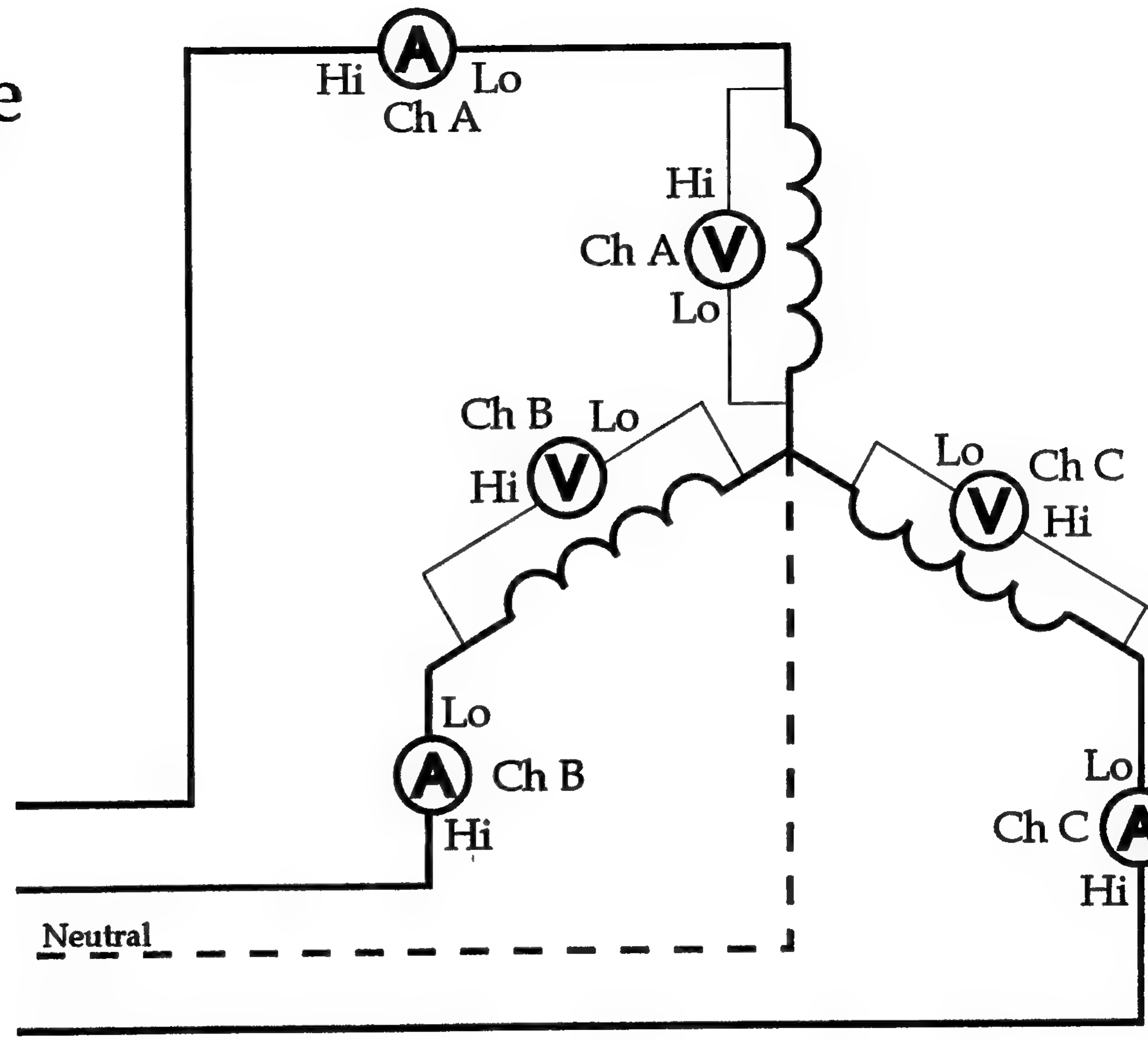
Quick Start : AB: 3-PHASE 3-WIRE

3-Phase 3-Wire 3-Meter [Delta]

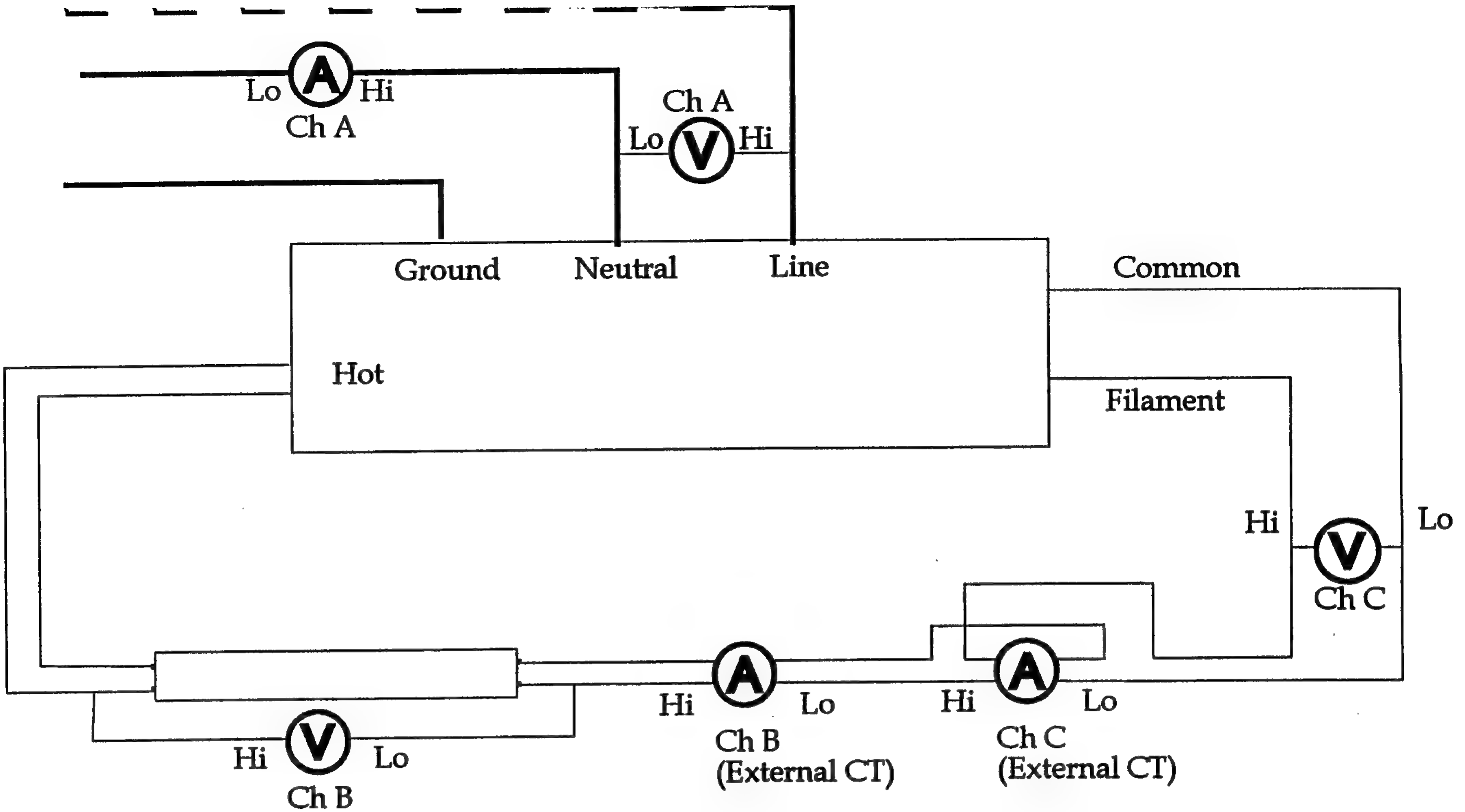


Quick Start : ABC: 3-PHASE 3-WIRE

3-Phase
4-Wire
[Wye]



Quick Start : ABC: 3-PHASE 4-WIRE



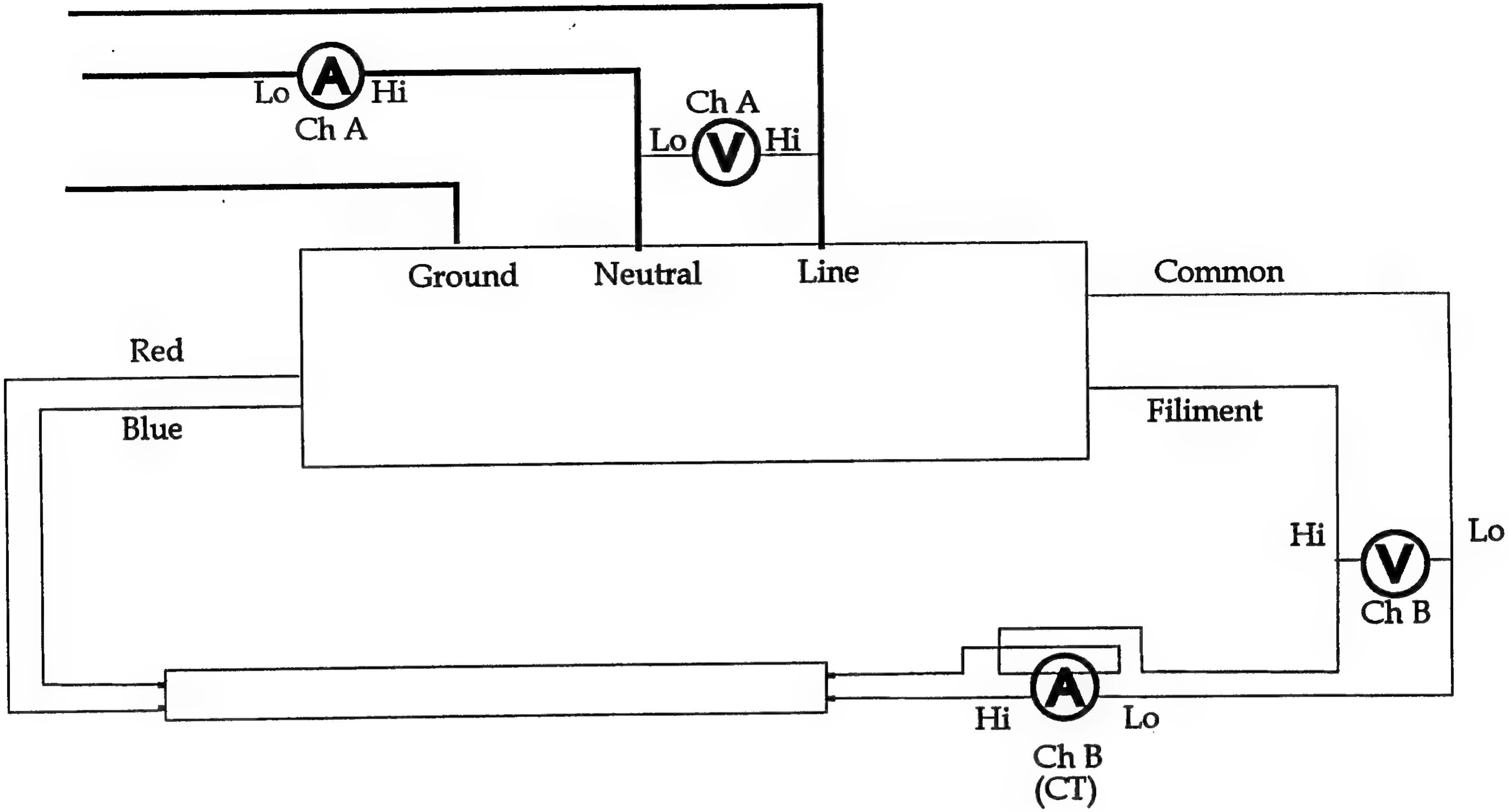
This is one possible way to measure a ballast and lamp.

Ch A will give Ballast volts, current, power, power factor, harmonics etc.

Ch B will give lamp voltage, total current, crest factor, etc.

Ch C will give filament voltage, current, power etc.

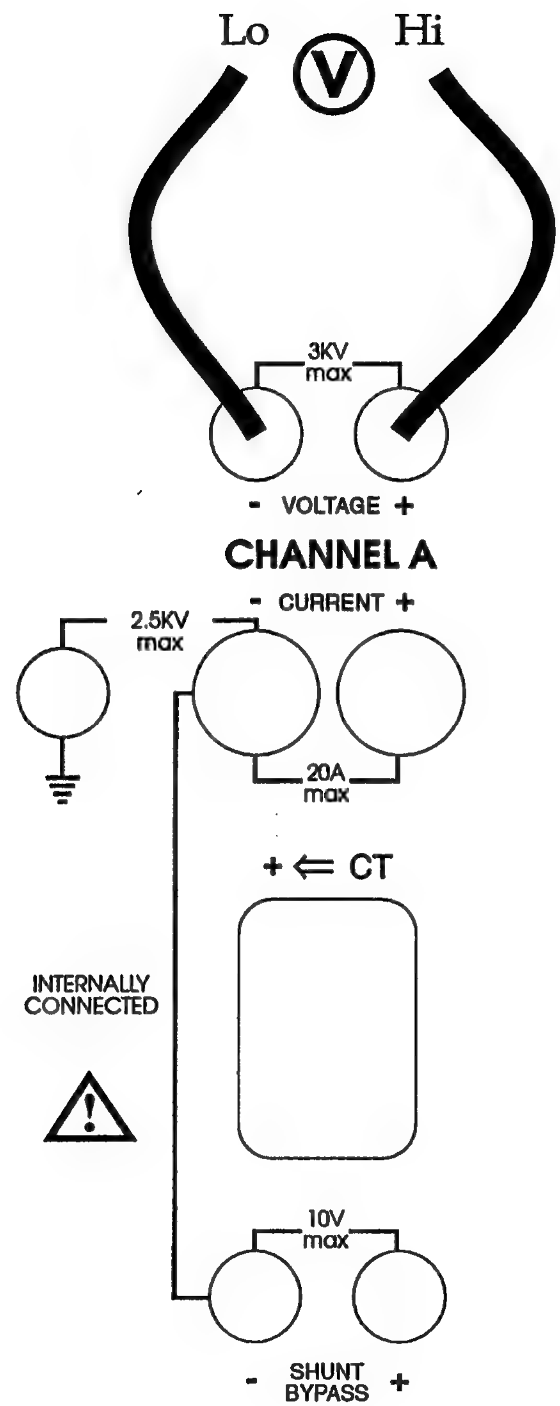
Meter will calculate total power (Ch A) minus lamp power (Ch B) plus filament power (Ch C) to give total efficiency / loss for the ballast.



This is one possible way to measure a ballast and bulb.

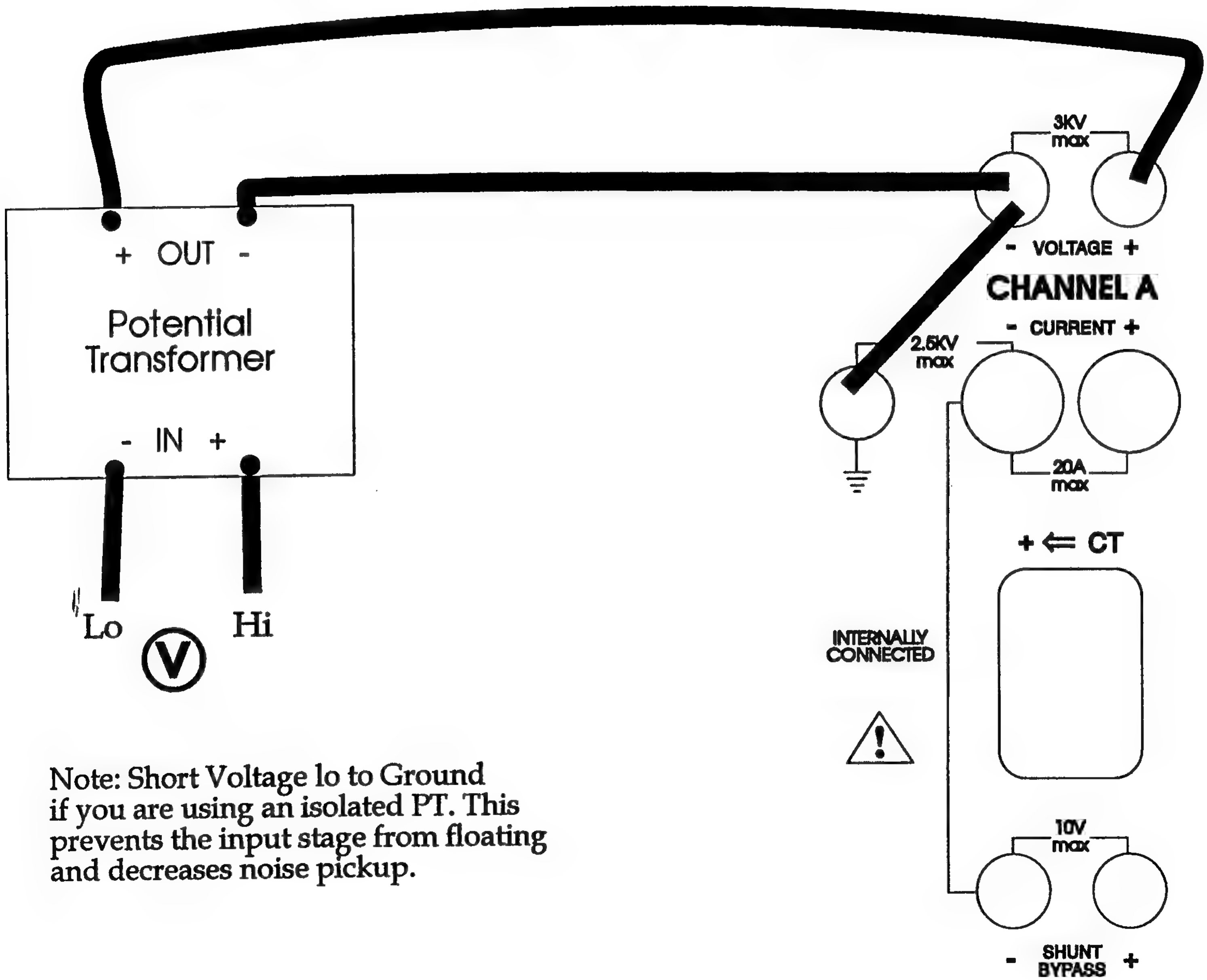
Ch A will give watts, power factor, harmonics etc.
Ch B will give filiment voltage, current, power etc.

Typical voltage connection.



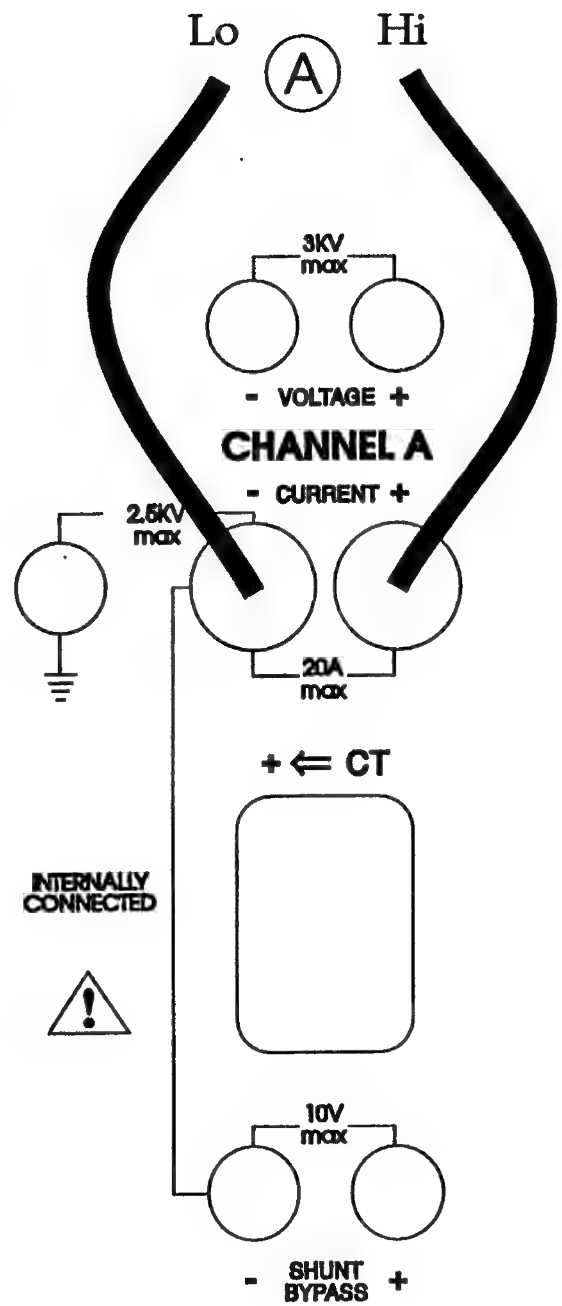
External PT Connection

Set the PT Ratio to match the PT you are using.



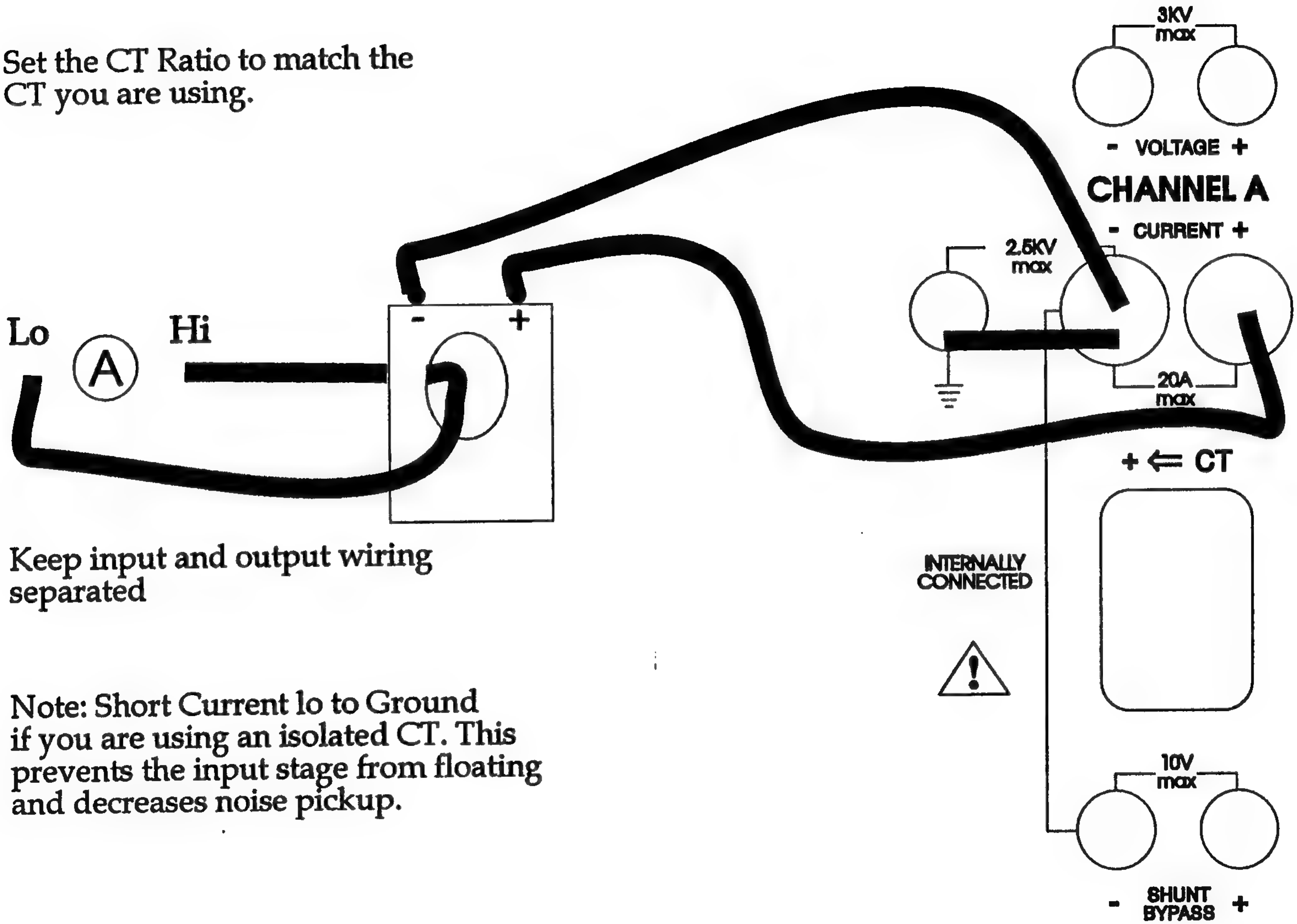
Note: Short Voltage lo to Ground if you are using an isolated PT. This prevents the input stage from floating and decreases noise pickup.

Shunt Connection



External CT Connection
Current/Current Transformer

Set the CT Ratio to match the CT you are using.



Keep input and output wiring separated

Note: Short Current lo to Ground if you are using an isolated CT. This prevents the input stage from floating and decreases noise pickup.

XITRON TECHNOLOGIES 2503AH AIO PINOUTS

ANALOG OUTPUT

Pins 1–13	Pins 14–25
Analog Output 0	Gnd
Analog Output 1	Gnd
Analog Output 2	Gnd
Analog Output 3	Gnd
Analog Output 4	Gnd
Analog Output 5	Gnd
Analog Outout 6	Gnd
Analog Output 7	Gnd
Analog Output 8	Gnd
Analog Output 9	Gnd
Analog Output 10	Gnd
Analog Output 11	Gnd
No Connection	

DIGITAL I/O
No DRO Option Fitted

Pins 1–13	Pins 14–25
Alarm 15	Alarm 2
Alarm 14	Alarm 1
Alarm 13	Alarm 0
Alarm 12	D17
Alarm 11	D16
Alarm 10	D15
Alarm 9	D14
Alarm 8	D13
Alarm 7	D12
Alarm 6	D11
Alarm 5	D10
Alarm 4	Gnd
Alarm 3	

DIGITAL I/O
DRO Option Fitted

Pins 1–13	Pins 14–25
DRO23	DRO10
DRO22	DRO9
DRO21	DRO8
DRO20	DRO7
DRO19	DRO6
DRO18	DRO5
DRO17	DRO4
DRO16	DRO3
DRO15	DRO2
DRO14	DRO1
DRO13	DRO0
DRO12	GND
DRO11	

250XAH Calibration Procedure

December 21, 1993
A. Armstrong

REQUIRED TEST EQUIPMENT :

FLUKE 5700A MULTI FUNCTION CALIBRATOR OR EQUIVALENT.
FLUKE 5725A 10AMP CALIBRATOR OR EQUIVALENT

Input Calibration

1. Ensure that there are no connections to any rear panel terminals nor through the rear panel Hall Effect CTs.
2. Press the "**Calibrate / Test**" key on the front panel.
3. Press the "MENU SELECT" key next to the "**Input Calibration**" display line.
4. The instrument now automatically sequences through an Input Calibration.
5. When completed, press the "ENTER" key to accept the Input Calibration. If a failure is reported then the user should rectify the fault condition before continuing.

External Calibration

An External Calibration may be performed on one channel at a time or several channels in parallel.

Voltage Calibration

Single Channel Connections :
Use Banana to Banana 36" long twisted pairs (Red & Black) or equivalent
250XA V-HI - 5700 Output HI (Red)
250XA V-LO - 5700 Output LO (Black)

Parallel Channels Connections :
Use Banana to Banana 6" long (Red & Black) or equivalent for connection between channels
Ch-A V-HI to Ch-B V-HI to Ch-C V-HI
Ch-A V-LO to Ch-B V-LO to Ch-C V-LO
Use Banana to Banana 36" long twisted pairs (Red & Black) or equivalent for connection between the 250xA and the 5700.
250XA V-HI - 5700 Output HI (Red)
250XA V-LO - 5700 Output LO (Black)

1. Press the "**Calibrate / Test**" key on the front panel.
2. Press the "MENU SELECT" key next to the "External Calibration" display line.

3. Set the Fluke 5700's output voltage to the level requested in the upper display line of the instrument, at a frequency of 400Hz.
4. Select OPERATE on the Fluke.
5. Press the "MENU SELECT" key(s) for the channel(s) being calibrated.
6. The instrument now displays the amplitude measured, and the percentage deviation from the nominal level, for each channel.
7. Allow the reading to settle for approximately 1 minute and press the "MENU SELECT" key(s) for the channel(s) being calibrated.
8. Press the "MENU SELECT 1" key. The instrument will increment to the next step.
9. Repeat steps 3 through 8 for each Voltage calibration step requested by the instrument.
10. Set the Fluke to STANDBY.

Bypass Calibration

Single Input Connections:
Use Banana to Banana 36" long twisted pairs (Red & Black) or equivalent
250XA BYPASS-HI - 5700 Output HI (Red)
250XA BYPASS-LO - 5700 Output LO (Black)

Parallel Connections:
Use Banana to Banana 6" long (Red & Black) or equivalent for connection between channels
Ch-A BYPASS-HI to Ch-B BYPASS-HI to Ch-C BYPASS-HI
Ch-A BYPASS-LO to Ch-B BYPASS-LO to Ch-C BYPASS-LO
Use Banana to Banana 36" long twisted pairs (Red & Black) or equivalent for connection between the 250xA and the 5700.
250XA BYPASS-HI - 5700 Output HI (Red)
250XA BYPASS-LO - 5700 Output LO (Black)

1. Set the Fluke 5700's output voltage to the level requested in the upper display line of the instrument, at DC. For voltage levels below 1V the 2V range of the Fluke should be used.
2. Select OPERATE on the Fluke.
3. Press the "MENU SELECT" key(s) for the channel(s) being calibrated.
4. The instrument now displays the amplitude measured, and the percentage deviation from the nominal level, for each channel.
5. Allow the reading to settle for approximately 1 minute and press the "MENU SELECT" key(s) for the channel(s) being calibrated.
6. Press the "MENU SELECT 1" key. The instrument will increment to the next step.
7. Repeat steps 1 through 6 for each Bypass calibration step requested by the instrument.
8. Set the Fluke to STANDBY.

Hall Effect Calibration

Single Channel Connections:
Use Banana to Banana 10' long 18 AWG teflon wire or equivalent

Put four turns of the wire through the sensor and connect one end to the 5725 or 5700 Output HI and the other end to the 5725 or 5700 Output LO. The 5725's output is used for currents higher than 2A.

Parallel Channels Connections:
Use Banana to Banana 10' long 18 AWG teflon wire or equivalent
Wrap four turns of the wire through all sensors and connect one end to the 5725 or 5700 Output HI Terminals and the other end to the 5725 or 5700 Output LO Terminals. The 5725's output is used for currents higher than 2A.

1. Set the Fluke 5700's output current to one quarter of the level requested in the upper display line of the instrument, at a frequency of 400Hz.
2. Select OPERATE on the Fluke.
3. Press the "MENU SELECT" key(s) for the channel(s) being calibrated.
4. The instrument now displays the amplitude measured, and the percentage deviation from the nominal level, for each channel.
5. Allow the reading to settle for approximately 1 minute and press the "MENU SELECT" key(s) for the channel(s) being calibrated.
6. Press the "MENU SELECT 1" key. The instrument will increment to the next step.
7. Repeat steps 1 through 6 for each Hall calibration step requested by the instrument.
8. Set the Fluke to STANDBY.

Shunt Calibration

Single Channel Connections:
Use Banana to Banana 36" long twisted pairs (Red & Black) or equivalant
250XA I-HI - 5725 or 5700 Output HI (Red)
250XA I-LO - 5725 or 5700 Output LO (Black)

Parallel Channels Connections:
Use Banana to Banana 6" long (Red & Black) or equivalant for connection between channels
Ch-A I-LO to Ch-B I-HI
Ch-B I-LO to Ch-C I-HI
Use Banana to Banana 36" long twisted pairs (Red & Black) or equivelant for connection between the 250xA and the 5725 or 5700.
250XA CH-A I-HI - 5725 or 5700 Output HI (Red)
250XA CH-C I-LO - 5725 or 5700 Output LO (Black)

1. Set the Fluke 5700's output current to the level requested in the upper display line of the instrument, at a frequency of 400Hz.
2. Select OPERATE on the Fluke.
3. Press the "MENU SELECT" key(s) for the channel(s) being calibrated.
4. The instrument now displays the amplitude measured, and the percentage deviation from the nominal level, for each channel.
5. Allow the reading to settle for approximately 2 minutes and press the "MENU SELECT" key(s) for the channel(s) being calibrated.
6. Press the "MENU SELECT 1" key. The instrument will increment to the next step.

7. Repeat steps 1 through 6 for each Shunt calibration step requested by the instrument.
8. Set the Fluke to STANDBY.

Completing The Calibration

1. Press any of the "MENU SELECT" keys to accept the calibration as being valid. Remove all connections from the instrument.
2. **Repeat the Input Calibration procedure.**